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NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

REVISED GUIDANCE FOR THE
ECONOMIC EVALUATION OF
DOD DATA PROCESSING SYSTEMS

by

Robert G. Lang

September, 1990

Thesis Co-Advisors: William J. Haga
David R. Henderson

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Virtually every aspect of national defense involves computer support. Automation extends to logistics, financial management and administration, health care delivery, command, control, and communications, intelligence, tactical operations, and weapon systems. Because automation requires scarce time and resources, you must understand the available alternatives and their costs and benefits. Economic analysis gives you the tools you need to evaluate and compare the alternatives.

Appendix E of this study gives you revised routines for doing an economic analysis. This guidance assumes that you are a novice in the field of economic analysis. Thus, the guidance develops slowly, from a few very basic economic and common sense principles. While you can easily apply these techniques to many investment problems, this study limits the guidance to the economic problem of choice within the ADP arena.

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Revised Guidance for the Economic Evaluation
of DOD Data Processing Systems

by

Robert G. Lang
Captain, United States Marine Corps
B.S., University of Idaho, 1982

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Author: Robert G. Lang

Approved by: William J. Haga, Thesis Co-Advisor

David R. Henderson, Thesis Co-Advisor

David R. Whipple, Chairman
Department of Administrative Sciences

ABSTRACT

Virtually every aspect of national defense involves computer support. Automation extends to logistics; financial management and administration; health care delivery; command, control, and communications; intelligence; tactical operations; and weapon systems. Because automation requires scarce time and resources, you must understand the available alternatives and their costs and benefits. Economic analysis gives you the tools you need to evaluate and compare the alternatives.

Appendix E of this study gives you revised routines for doing an economic analysis. This guidance assumes that you are a novice in the field of economic analysis. Thus, the guidance develops material slowly, from a few very basic economic and common sense principles. While you can easily apply these techniques to many investment problems, this study limits the guidance to the economic problem of choice within the ADP arena.

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I. INTRODUCTION

A. THE PURPOSE OF PUB 15 7000

In 1980, the Naval Data Automation Command (NAVDAC) was responsible for Automatic Data Processing (ADP) policy. When publishing PUB 15 7000 "Economic Analysis Procedures for ADP" (Pub 15), the NAVDAC Commander [Ref. 1] stated that the publication would provide basic guidance for the conduct and review of economic analysis. NAVDAC intended for the publication to be consistent with Secretary of the Navy Instruction (SECNAVINST) 7000.14.B, "Economic Analysis and Program Evaluation for Navy Resource Management." The publication also would highlight elements of economic analysis as they pertain to ADP.

B. USES OF PUB 15 7000

According to Argue [Ref. 2:p. 11], since the Bureau of Census introduced the first general purpose computer into the federal government, all government agencies have become increasingly dependent upon computers to do their mission. Due to the cost, poor reliability and maintenance requirements of the early computers, in 1951 the government projected that it would use no more than a dozen or so computers by 1970. Obviously, no one saw the massive proliferation of computers that occurred nor that they would pervade into almost every aspect of defense endeavors. Today, the Department of Defense (DOD) uses computers to support its logistics, financial management and administration, health care delivery, command and control, communications, intelligence, tactical operations and weapon systems.

Because computer systems require a major investment of time and resources, it is important that you understand all reasonable alternatives and the costs and benefits associated with each. The economic analysis is a tool you need to evaluate alternatives and reduce them to a common basis providing for the ease of comparison. In this manner, Pub 15 was to establish a procedural routine to conduct economic analysis. Via the Commanding Officer, Naval Publication and Form Center (NAVPUBFORMCEN), Philadelphia, NAVDAC distributed their publication to 70 bureaus, commands, squadrons and other facilities so that they could use the publication to do their economic analysis.

Additionally, the Naval Postgraduate School (NPS) uses the manual in several of their courses. According to the Department of the Navy [Ref. 3:pp. 105-109], MN3307, ADP Acquisition is a course introducing management principles, ideas and issues concerning the Federal government's acquisition of ADP. This course touches base with the manual as the Federal Information Resources Management Regulation (FIRMR), paragraph 201-30.009 requires that we do an economic analysis of alternative resources. IS3170, Economic Evaluation of Information System, uses Pub 15 in detail as the course professor dedicates approximately one-third of the three-month session to cover the economic analysis of ADP systems. Pub 15 appeared to be the most suitable text for this course.

II. APPLICATION PROBLEMS

A. Background

The scope of this study limited its observation of the application of Pub 15 to that of NPS's application of Pub 15 as a classroom textbook. From student feedback and experience, this study made several observations concerning the original Pub 15.

B. Not Readily Applicable as a User's Document

Several inherent traits prevented the full assimilation of the original Pub 15 into the classroom. While much of the observed resentment may be the students displaying their personal preferences, this study could not ignore the reaction of the students. Generally, the students did not view Pub 15 as a readily applicable, user friendly, guide into the world of economic analysis. In part, their failure to take Pub 15 to heart may stem from the PUB's failure to apply several notable user documentation rules.

1. The Four Rules for a Useful User's Document

According to Weiss [Ref. 4:pp. 18-19], successful document engineering relies on the subject matter meeting four specific criteria. These are: availability, suitability, accessibility and readability.

a. Availability

Availability, in its simplest form, means that you easily can obtain documentation concerning your area of interest. Recently, as we have automated many of our work spaces and recreation areas too, the meaning of availability now also questions the medium for the data. Do you have convenient access to it?

b. Suitability

Suitability means that the material aligns with your interests and your current task. Suitability is the degree to which a manual fits the interests and supports the tasks of its users. A document with relevant subject matter and explanations would be a suitable document. A document with "dated" material and specific references to what used to be vogue and now is passe is less suitable.

c. Accessibility

Accessibility means that you find the document's organization comfortable. This organization allows you to extract, without delay, the information contained in the document. Text becomes more accessible when it is free from distracting features such as spelling mistakes, inconsistent conventions and terminology, or poor reproductive qualities.

d. Readability

Readability means the ease with which the user can read a passage from the document. Often, we express readability with a grade level of difficulty. Still, this measure does not necessarily prove that a document is more readable than another. As most readability indices use sentence length and word length to estimate readability. Two simple actions will help you ensure the document scores itself as fluent and simple to read. First, reduce the number of words per sentence. Second, reduce the use of "hard words," those with three or more syllables.

2. Use of Complicated Words and Fat Phrases

According to SECNAVINST 5216.5C [Ref. 5:pp. 1-9 - 1-14] military correspondence and documentation is notorious for using complicated words and fat phrases.

Instead of saying *start*, many military writers use *commence*. Instead of using *help*, the military version is *facilitate*. While not alone in its use of fat words, some writers of military manuals, as they *try to give us their best advice*, go on a *quest to promulgate the optimum realization of their accumulated wisdom.*

3. Writing at the User's Reading Level

According to Scott [Ref. 6:pp. 7-8], writing to our readers level is very important. Our readers will not pursue our literature if we confuse them or write above their level. Poorly written and improperly leveled literature wastes the time we used to write it. It wastes the paper on which we published it. Ultimately, it wastes the energy our readers use trying to figure out our meaning.

Several indices emerge from contemporary style and prose textbooks. According to Weiss [Ref. 4:p. 154] and Reference Software International [Ref. 7:pp. 6-3 - 6-4], the Flesch-Kincaid reading index provides a *grade-level-of-difficulty* for the document. Essentially, if you apply the index to the publication, it gives you a number that corresponds to the number of years of schooling you would need to understand the document. For example, 11 means that a high school junior should understand most of the publication. A 14 means that a reader with two years of college should understand most of the writing. Weiss [Ref. 4:p. 154] notes that when writing for the public, we should keep our work at a tenth grade level.

C. THE PASSIVE VOICE

According to SECNAVINST 5216.5C [Ref. 5:p. 1-19], a passive verb is a verb conjugating any form of *to be*, such as: am, is, are, was, were, be, being and been; and the past participle of another verb, that is one ending in *en* or *ed*.

1. SECNAVINST 5216.5C

SECNAVINST 5216.5C gives DON standards for the quality of writing, correspondence formats and paperwork management. Besides the five topics in the first chapter, the instruction states the need to avoid using passive verbs and strive to use the active voice in all naval correspondence.

2. Inferiority of the Passive Voice

Many texts expose the inferiority of the use of the passive voice in writing. When the original Pub 15 uses the passive voice, it subtracts meaning from its content. According to Strunk [Ref 8:pp. 18-19], by saying "basic principles must be incorporated," instead of saying "you must incorporate three basic principles," the manual suppresses identity, that is, a specific detail, and puts distance between the implied subject and definite action.

According to Hall [Ref. 9:pp. 79-80], the passive voice is indefinite. For example, when the original Pub 15 [Ref. 10:p. 1-1] states, "Three basic principles must *be incorporated* in the economic analysis," the Pub doesn't direct who must incorporate these principles. Are you deliberately to pursue the incorporation or does the economic analysis do this function automatically?

An attempt to make the passive voice more definite still leaves the sentence less direct, less bold and less concise than the active voice. For example, the modified passive sentence states, "Three basic principles must be incorporated *by you* in the economic analysis." In comparison, the active voice makes the sentence more concise and specifically directs who must incorporate three principles. For example, the revised manual [Ref. 11:p. 1-1] states, "You must incorporate three basic principles in the economic analysis."

3. Repeated Occurrences Throughout the Document

This study statistically sampled the original publication to project the number of occurrences of the passive voice. The original Pub 15 has 124 pages in its main text. This does not count cover sheets, table of contents, foreword, appendices or other miscellaneous marker pages.

Using computer generated random number ranging from one to 124, this study selected 20 pages and tallied the use of the passive voice within those pages. The sample contained 118 occurrences of the passive voice. Given a sample error of five percent, the original publication had 875 occurrences of the passive voice.

Another sample selecting pages from the publication with text only. The average text-full page contains 8.06 occurrences of the passive voice. Appendix A displays the relevant statistics.

D. UNCLEAR OR CONFUSING EXAMPLES

Perhaps, no manual can be everything to everybody. Yet, given that NPS applied the manual as a text for graduate students with at least 16 years of education, you might

expect that the class would find the publication usable without undo confusion nor intervention from the professor. Yet, the original version of Pub 15 proved to be perplexing. This study observed that the problems amongst the student-users of the publication fell into two categories:

1. Ideas and Statements Not Sufficiently Illustrated

One principle applicable to the construction of a user friendly manual is the use of exhibit and examples to illustrate ideas that may be unclear to the user. According to Weiss [Ref. 4:pp. 18-19], every new idea should have an accompanying illustration and that illustration should be *redundant* with the text, not a supplement to the text.

The original Pub 15 did not provide adequate illustrations nor examples to remove doubt or clarify questions among the students. For example, the original publication [Ref 10:p. 9-1] flatly states "A low discount rate gives little attention to the time value of money." Also, "A high discount rate on the other hand, would tend to place greater emphasis on today's costs." The contention within the class was that the statement, while perhaps true, offered no proof that it was true, nor did it offer any suggestion to the students why it was true.

2. Given Examples Not Sound Economics

In the original document, Chapter 12 attempts to explain the use of the Savings/Investment Ratio (SIR) as a measure of the financial benefits for an investment. While the first part of this chapter creditably explained the use of the SIR, the class became confused and questioned the validity of the SIR when the original Pub [Ref 10:p. 12-4] says that the SIRs "*provide the decision-maker with a means of comparing 'profitableness' of various investment projects . . .*" but then goes on to say [Ref 10:p. 12-5] "*the SIR can be*

misleading. Therefore it is suggested that the SIR technique be reserved . . ." for several rare and seldom encountered circumstances.

Here, the justification for using the SIR has the reader compare an alternative with the status quo. Still, in the example [Ref. 10:p. 12-6], the alternative involves leasing equipment, instead of buying it. Where a lease lacks up-front "investment" costs, the computation of the SIR would involve division by zero. At this point, the example becomes contrived as it included a $700 terminal value, which fittingly prevents division by zero. Not withstanding, the class demanded to know what to do if they were leasing equipment that lacked up front costs and salvage value.

E. IMPROPER TREATMENT OF INFLATION

In the original publication [Ref. 10:pp. 4-1 - 4-4], Chapter 4 uses four pages to discuss the effect of inflation upon an economic analysis. Additionally, Appendix D of the original publication [Ref. 10:pp. D-1 -D-17] uses 17 pages of various discount factors that correspond to differential rates of inflation. As with the lack of sufficient examples and illustrations to prove and reinforce the learning experience, the chapter on the treatment of inflation make broad, sweeping statements that do not stand-up to numerical analysis. More importantly, Pub 15 requires that the user apply a "two-phase approach." First, you must do your economic analysis in constant dollars. Then, if you somehow decide that inflation is important, you are to re-do your analysis, this time using current dollars.

This treatment is a cumbersome process and the original Pub didn't sufficiently explain why we need the process. This allowed members of the IS3170 class developed other ideas about inflation with some interesting results.

III. RESOLUTION OF PROBLEMS

A. BACKGROUND

Recognition of a problem may be the first step to resolving it. If that is true, then the users of Pub 15, in particular the students at NPS, took the first step. To have an opportunity to collect their thoughts and pursue them to the roots of their frustration seemed the next logical step.

B. REDESIGNED TO APPEAL AS A USER'S DOCUMENT.

This study assumed that Pub 15 met the requirements of the SECNAVINST 5216.5C. Thus, this study tried to change Pub 15 into a readily applicable user's document while retaining its essential information concerning economic analysis. This study sought to make a new user appealing Pub 15 through the appropriate use of the four useful user document rules and ordinary simplification.

1. The Four Rules for a Useful User's Document

a. Availability

This study did not view availability as a problem associated with Pub 15 nor its use. As noted earlier, Pub 15 has wide distribution throughout the fleet. Although the DON continues to speak of paperless ships and office spaces, to anyone who works with the Navy, clearly the paperless environment is some years away. Besides, even the Navy finally floated a paperless ship, we are far from having a paperless classroom only with electronic textbooks.

b. Suitability

Throughout the new document, this study made subtle changes to Pub 15, enhancing its suitableness. Suitability is having material aligned with your current task and interests. This study removed dated matter and inserted current examples.

In this manner, the original Pub 15 continuously refers to inflation. In the late 1970s, as the nation experienced double digit inflation approaching 20 percent, the material may have been appropriate. Now, it is not.

Another example of dated material come from Chapter 7 and its discussion of economic life and project life. The original Pub 15 [Ref 10:p. 7-1] uses a *college freshman buying a car*, for school use, *as his grandfather will buy him a new one upon graduation*. This example does not fit for several reasons. First, cars are popular possessions among high school students; a college freshman buying a car has little novelty. Second, many universities have limited parking space; buying a car to commute to school may be impractical. Finally, Pub 15 concerns the *economic analysis of computers, not automobiles*; the automobile example is distracting. The revised Pub [Ref. 11:p. 7-1] changed the car example into a college freshman buying a computer.

c. Accessibility

Accessibility extends to a document's organization and how well it lets you extract its information. The lack of distractors such as spelling mistakes, inconsistent wording and poor reproductive qualities improves accessibility. While spell-checking and grammatical proofing software can resolve some concerns of accessibility, the original Pub 15 did not use several available features to highlight key topics. Such features include using the underlining feature of the word processor, shown

here. Another way to highlight material uses **bold print**, or **Bold Print with Key Words Capitalised**, shown here. Finally, Pub 15 could have used *italic characters*, or ***bold italic characters***, shown here. NAVDAC most likely produced the original Pub 15 using a microcomputer with an impact printer such as the daisy-wheel spinning Diablo 630. Still, even this printer supports underlining, **bold print** and *italic characters*. This study used these features to improve Pub 15's accessibility.

d. Readability

Given that we can quantify the readability of a document and one method of quantifying its readability is through indices using sentence length and word length and the use of *simple* vice *hard* words, then the original Pub 15 was far from a readable document. As Appendix B shows, the original Pub 15 used words such as disseminate instead of distribute, indicate instead of show and determine instead of find. Besides overstated and pretentious wording, the original publication used redundant words, vague adverbs and informal, colloquial speech.

While these are two examples of the needless misuse of hard words, they show the verboseness of the original Pub 15. This study used Grammatik IV to flag and remove the needless use of hard words from the revised document.

2. Use of Complicated Words and Fat Phrases

The original Pub 15 repeatedly used complicated wording and fat phrases, like much of our military writing. Instead of stating every instance where the revised Pub 15 changed wording to make it simpler, here is one example, with emphasis added to show its use of fat phrasing. "The Mission Life is that *period of time over which* a need for the *asset or program is anticipated.*"[Ref. 10:p. 7-1] A *period of time* is redundant. *Over*

which means when. *The asset or program* really means an object or something you use. The revised Pub 15 [Ref. 11:p. 7-1] simply states, "The Mission Life is the period when you need something." This is simpler.

3. Writing at the User's Reading Level

This study assumed that the Flesch-Kincaid Score is a valid measure of readability and that the usefulness of a document goes hand-in-hand with its grade level of difficulty. Using this score, the original Pub 15 is not a highly readable document. Appendix C is a Grammatik IV analysis of the original and revised Pub 15. As this analysis shows, the original Pub 15 repeatedly received Flesch-Kincaid grade levels of 13, 14 and 15. By using simpler words and fewer complicated phrases, the revised document consistently scored 12 or fewer points. While this does not meet the normal reading level of ten, this is an improvement.

C. THE PASSIVE VOICE

To sparingly use the passive voice is not bad. Some exceptional uses of the passive voice enhances our writing and makes its point better than the active voice. For example, in the revised Pub 15 [Ref. 10:p. 4-4], example 4-2 addresses raising out-year costs by an inflation factor. Because the sequence of years, that is Year 0, Year 1, Year 2 and so forth, provide a simple, readily recognizable, logical sequence, saying "Year 1 costs are multiplied by 1.05" and "Year 2 costs are multiplied by $(1.05)^2$" provides a clear example. To say "$(1.05)^3$ multiplies the Year 3 costs" could obscure the year-by-year progression.

Despite the noted inferiority of the passive voice and directives that discourage its use, Pub 15 repeatedly used the passive voice. For example, [Ref. 10:p. 5-1] uses the passive voice four times. [Ref. 10:p. 3-1] uses the passive voice 19 times.

Instead of stating every instance where the revised Pub 15 changed wording to make it simpler, here is one example, with emphasis added to show the passive voice. The original Pub 15 [Ref 10:p. 3-1] states, "Any cost that *will be incurred* no matter what choice *is made*, any cost that must *be borne* regardless of the decision at hand, is not a cost of that particular choice or decision and need not *be included* in the analysis." All the italicized words are passive verbs. The revised Pub [Ref. 11:p. 3-2] states, "Costs that you will incur no matter which alternative you choose do not belong in your analysis."

This study used Grammatik IV to count the use of the passive voice in each chapter as a proportion of the total sentences. Using Minitab to compile additional statistics, the expected occurrence of the passive voice is 26.24 percent throughout the original Pub 15. The expected usage of the passive voice in the revised document was less than one percent.

D. UNCLEAR OR CONFUSING EXAMPLES

1. Ideas and Statements Not Sufficiently Illustrated

The economic analysis of automated data processing systems is not a mainstream topic taught in most high schools nor undergraduate programs. Accordingly, the originator of Pub 15 could have anticipated that the publication's material would be new to its readers. Given that the material is new, the publication should have used many examples and illustrations to clarify and amplify key points. It did not.

For example, the original Pub [Ref 10: p. 9-1] states, "A low discount rate gives little attention to the time value of money." Also, " A high discount rate, on the other hand, would tend to place greater emphasis on today's costs." The lack of a supporting illustration combines with the passive-bound, complex, written explanations to obscure its meaning. Together, they did little to show you why this is true and why this is important.

The new publication uses an orderly approach to prove this point. First, the text describes two cash flows occurring at separate times, with different absolute values. Next, the text uses a figure *redundantly* showing the cash flow, their non-synchronous occurrences. Then, the text uses a table to show that the two cash flows have equal accumulated present values, given a ten percent discount rate. Additionally, the text uses a similar table based upon the same cash flows to continue the example. This shows that a low discount rate (one percent) produces a higher accumulated present value when the cash flow occurs later. Finally, the text uses another similar table based upon the same cash flows to make its last point. That is, a high discount rate (19 percent) produces a higher accumulated present value when the cash flow occurs earlier.[Ref. 11:pp 8-5 - 8-8]

2. Given Examples Not Sound Economics

As noted earlier, the original Pub 15 [Ref 10:pp. 12-1 - 12-6] gave an example of a Savings/Investment Ratio (SIR) that you couldn't use to compare like investments. This is because the original publication is inconsistent and treats money invested today and money invested later, differently. The original publication treats current payments to buy a resource different from the payments you make to lease a resource. The timing should affect only the discount factor. The ultimate ownership of the resource does not have special significance.

According to the original Pub [Ref. 10:p. 10-1], you can compare cash flow equitably, given that you can identify the timing of the cash flows and apply an appropriate discount rate. The use of the cash flow does not affect its opportunity costs, its alternative uses, nor its present value to the organization. When you apply a cash flow to obtain a resource, you do not change its present value. Buying the resource outright, taking a loan to buy it outright, renting it with a lump sum payment, or leasing the resource with recurring payments *does not affect the fundamental present value of the cash flow.*

Therefore, the revised publication [Ref. 11:p. 12-2] provides a SIR that incorporates the idea of present value. In this manner, the SIR reflects present value and its formulation is:

$$SIR = \frac{PV_S}{I_S}$$

This formulation uses the discount factors to adjust the cash flows according to the time value of money. It does not distinguish between the uses of the money. Thus, buying a resource today using a cash flow with a present value of $100 has the same impact as renting or leasing the resource for the same present value of $100.

Unlike the SIR in the original manual, the revised formulation of the SIR fits all cases. You can use the SIR to decide which alternative has the least costs, or greatest savings, compared to another investment. This allows you to compare several alternatives against the status quo and against each other. This also removes the need to do a separate present value analysis.

E. THE PROPER TREATMENT OF INFLATION

Chapter 4 of the original publication [Ref. 10:pp. 4-1 - 4-4] spent much time explaining how inflation affects your economic analysis, how you account for inflation and

how to estimate inflation. Unfortunately, the original publication does not reflect sound economics in its discussion.

An economic analysis is a useful decision making tool when you accurately can estimate future costs and benefits. Inflation is a general rising level of prices and as a rule, inflation affects all items equally. While the *absolute price* changes for all items, given inflation, their *relative price does not.* Since, in this relative way, all things remain equal, inflation does not affect the present value of future cash flows. According to Henderson and Haga [Ref. 12], you can ignore the affects of inflation. You do not specifically need to account for inflation in your calculations.

This study found lacking the matter-of-fact statements concerning inflation from the original publication. To show why you can ignore inflation, Chapter 4 of the revised manual [Ref. 11:pp. 4-1 - 4-6] incorporated the Henderson-Haga article [Ref. 12], in depth.

IV. CONTRIBUTIONS TO THE NAVAL COMMUNITY

A. KEEP INFLATION OUT OF YOUR ANALYSIS

Giving a correct procedure to handle inflation does more than remove the four pages of erroneous information from Chapter 4 and the additional 17 pages of Appendix D of the original publication. In the original publication, the treatment of inflation is a cumbersome process. Yet, the publication does not explain with any depth of reasoning the necessity of the process.

In the revised publications, the correct handling of inflation states that you should ignore inflation and avoid the previously required "two-phase approach." The correct methodology uses definitive wording. It does not leave you to decide, somehow, if inflation is important and should you redo your analysis, this time using current dollars.

B. OTHER USES FOR THE SAVINGS/INVESTMENT RATIO

The original publication [Ref 10:p. 12-1] developed the Savings/Investment Ratio (SIR) as a measure of the financial benefits for an investment. Yet, the publication warns that SIRs "*. . . provide the decision-maker with a means of comparing 'profitableness' of various investment projects . . .*" [Ref. 10:p. 12-4] and continued to say "*. . . the SIR can be misleading. Therefore, it is suggested that the SIR technique be reserved . . .*" in its application.[Ref. 10:p. 12-5] You can not use the SIR to compare projects.

The revised publication [Ref. 11:p 12-2] incorporates the idea of present value into the SIR. Discounting future expenditures allows you to combine non-recurring and recurring investment costs and equitably compare them to other investment alternatives.

This prevents alternatives with low initial costs but high out-year costs from appearing to have a higher, more favorable SIR than alternatives with heavy initial investments.

C. TEXTBOOK USABLE GUIDE FOR ECONOMIC ANALYSIS

To find if the students preferred the original or revised manual, this study sampled two sections of the IS3170 class about to use a revised version of the publication. Of the 60 samples returned, 26 students preferred the modified version of the manual, 14 preferred the original version and 20 showed no preference. Nearly two to one, the students preferred the revised publication. Further testing of the hypothesis, as Appendix D shows, was a statistically significant result.

Appendix E is the revised publication. This appendix represents the work this study accumulated over three six-month cycles. In each cycle, the first three months reviewed the existing work and revised the publication. The next three months injected the revised publication into the classroom environment. In this manner, this study incorporated the suggestions, comments and criticisms of 150 or more people who used one version or another of the publication.

LIST OF REFERENCES

1. Naval Data Automation Command, UNCLASSIFIED letter Serial 90-148/749 to Distribution List, Subject: Economic Analysis Procedures for ADP; promulgation of, 12 March 1980.

2. Argue III, A. C., *Acquisition of Automated Data Processing in the Navy*, MN3307 ADP Acquisition Reading Book I, (Class Handout), Naval Postgraduate School, Monterey, California.

3. U.S. Department of the Navy, *Naval Postgraduate School Catalog, Academic Year 1989*, Government Printing Office, Washington, DC, 1988.

4. Weiss, E. H., *How to Write a Usable User's Manual*, ISI Press, 1985.

5. U.S. Department of the Navy, Office of the Secretary, *Secretary of the Navy Instruction (SECNAVINST) 5216.5C, Department of the Navy Correspondence Manual*, Navy Publications Form Center (NAVPUBFORMCEN), Philadelphia, PA, 1983.

6. Scott, D. H., *Secrets of Successful Writing*, Reference Software International, 1989.

7. Reference Software International, *Grammatik IV, The Easiest Way to Improve Your Writing*, 1989.

8. Strunk Jr., W., *The Elements of Style*, McMillan Publishing Co., Inc., New York, 1988.

9. Hall, D., *Writing Well*, 3rd ed., Little, Brown and Company, 1979.

10. Naval Data Automation Command, Publication 15 7000, *Economic Analysis Procedures for ADP*, by D. C. Zimmerman, December, 1980.

11. Lang, R. G., "Revised Economic Analysis Procedures," unpublished manuscript uses in IS3170, Naval Postgraduate School, Monterey, California, 1990.

12. Henderson D.R., "How to Account for Inflation When Taking Present Value," with accompanying numerical example by William J. Haga, unpublished paper presented to IS3170 class, Naval Postgraduate School, Monterey, California, September 13, 1989.

APPENDIX A

STATISTICAL ANALYSIS OF THE PASSIVE VOICE

This appendix contains statistical information supporting the changes made to the publication. The page, "Grade Level of Original and Revised Publication" used the Grammatic provided grade levels for the 17 chapters as input. The reading grade level of the original publication shows up as "GRADEORI" (grade, original). The mean reading level is 12.24 years and ranges from 10 to 15 years. The reading grade level of the revised publication shows up as "GRADEREV" (grade, revised). The mean reading level is 10.47 years and ranges from eight to 12 years.

The next page, "Passive Voice per Chapter of Original and Revised Publication" used the Grammatic provided "passive voice percentage" for each chapter as input. The passiveness of the original chapters shows up as "PASS_ORI" (passiveness, original). The mean reading level is 26.24 percent and ranges from 18 to 39 percent. The passiveness of the revised publication shows up as "PASS_REV" (passiveness, revised). The mean reading level is 0.47 percent and ranges from zero to two percent.

The next page, "Passive Voice, Random and Full-Page Samples" used a random sample of twenty pages and a selective sample of 17, all text pages, from the original publication, to project expected occurrences of the passive voice. The passiveness of the random sample shows up as "RANDOM" (random sample). The mean passiveness level is 6.25 occurrences per page and ranges from zero to 17. As the original publication has 124 pages of text, you expect the Pub to have 775 uses of the passive voice.

The passiveness of pages that have text only shows up as "FULLPAGE" (full page of text). The mean passiveness level is 8.06 occurrences ranges from four to 19. You cannot use this sample to project a passiveness level for the entire document. Still, for any page full of text, you would expect to encounter eight occurrences of the passive voice.

The final pages, "Random Sample Table" and "Selected Sample Table" shows the random and selected samples.

```
MTB >
MTB >
MTB >
MTB >
MTB >
MTB > tint c5

              N      MEAN     STDEV  SE MEAN   95.0 PERCENT C.I.
GRADEORI     17    12.235     1.200    0.291  (  11.618,  12.853)

MTB > boxplot c5

                                    -----------
               *          ----------+          I----------          *
                                    -----------
            ----+---------+---------+---------+---------+---------+--GRADEORI
             10.0       11.0       12.0       13.0       14.0       15.0

MTB >
MTB >
MTB >
MTB >
MTB >
MTB >

MTB >
MTB >
MTB >
MTB >
MTB >
MTB > tint c6

              N      MEAN     STDEV  SE MEAN   95.0 PERCENT C.I.
GRADEREV     17    10.471     1.179    0.286  (   9.864,  11.077)

MTB > boxplot c6

                                    --------------
               *             -------------+              I------------
                                    --------------
            ----+---------+---------+---------+---------+---------+--GRADEREV
             8.00       8.80       9.60      10.40      11.20      12.00

MTB >
MTB >
MTB >
MTB >
MTB >
MTB >
```

```
MTB >
MTB >
MTB >
MTB >
MTB >
MTB > tint c3

              N      MEAN     STDEV   SE MEAN    95.0 PERCENT C.I.
PASS_ORI     17     26.24      6.13      1.49  (    23.08,    29.39)

MTB > boxplot c3

                      ----------------------
                 -----I                +      I----------------------
                      ----------------------
               -------+---------+---------+---------+---------+-------PASS_ORI
                    20.0      24.0      28.0      32.0      36.0

MTB >
MTB >
MTB >
MTB >
MTB >
MTB >

MTB >
MTB >
MTB >
MTB >
MTB >
MTB > tint c4

              N      MEAN     STDEV   SE MEAN    95.0 PERCENT C.I.
PASS_REV     17     0.471     0.717     0.174  (    0.102,    0.840)

MTB > boxplot c4

             -------------------------
             +                       I-------------------------
             -------------------------
             +---------+---------+---------+---------+---------+------PASS_REV
           0.00      0.40      0.80      1.20      1.60      2.00

MTB >
MTB >
MTB >
MTB >
MTB >
MTB >
```

```
MTB >
MTB >
MTB >
MTB >
MTB >
MTB > tint c1

              N      MEAN     STDEV   SE MEAN    95.0 PERCENT C.I.
RANDOM       20      6.25      4.60      1.03   (     4.10,     8.40)

MTB > boxplot c1


                    ----------------------
            -------I           +          I----------------------
                    ----------------------
            +---------+---------+---------+---------+---------+------RANDOM
          0.0       3.5       7.0       10.5      14.0      17.5

MTB >
MTB >
MTB >
MTB >
MTB >
MTB >

MTB >
MTB >
MTB >
MTB >
MTB >
MTB > tint c2

              N      MEAN     STDEV   SE MEAN    95.0 PERCENT C.I.
FULLPAGE     17     8.059     3.881     0.941   (    6.063,   10.055)

MTB > boxplot c2


                    -----------------
              ----I          +      I-------
                    -----------------
            +---------+---------+---------+---------+---------+------FULLPAGE
          3.0       6.0       9.0       12.0      15.0      18.0

MTB >
MTB >
MTB >
MTB >
MTB >
MTB >
```

Random Sample Table

RANDOM SAMPLE OF PASSIVE VOICE IN PUB 15

Sample Number	Random Number Generated	Corresponding Page Number	Number of Uses of the Passive Voice
1	104	16-1	5
2	94	14-1	5
3	103	15-5	0
4	71	10-21	0
5	23	4-1	11
6	10	2-6	11
7	70	10-19	0
8	24	4-2	17
9	7	2-3	7
10	53	9-4	9
11	5	2-1	4
12	91	13-3	9
13	97	14-4	6
14	89	13-1	5
15	20	3-9	10
16	42	7-5	0
17	47	8-2	7
18	75	11-3	1
19	3	1-3	8
20	40	7-3	10

Selected Sample Table

FULL PAGE SAMPLE OF PASSIVE VOICE IN PUB 15		
Sample Number	Corresponding Page Number	Number of Uses of the Passive Voice
1	1-1	11
2	2-1	4
3	3-1	19
4	4-1	11
5	5-1	4
6	6-1	6
7	7-1	12
8	8-1	10
9	9-1	6
10	10-1	8
11	11-2	4
12	12-1	6
13	13-1	5
14	14-2	8
15	15-1	8
16	16-1	5
17	17-1	10

APPENDIX B

WORDY, CLICHE, AND COLLOQUIAL SPEECH

This appendix shows some of grammar and stylistic errors of the original publication. This appendix does not provide a comparison of the original and revised document because that would not provide useful information. The study used GRAMMATIC IV to remove the noted errors from the revised publication.

The following page, "Long Winded or Wordy Speech," lists various words that we should avoid using in text and the GRAMMATIC IV suggested replacements. The next page, "Cliche Words and Phrases," shows cliches from the original publication. The next page, "Redundant Words" shows redundant words from the original publication and the correct usage. The next page, "Overstated and Pretentious Words" shows words from the original publication and suggested replacements.

Long-winded and Wordy Original Publication Words		
as to how - how	by the use of - by, by using	may well be - may be, might
as well as - also	be one that - be	might possibly - might
assuming that - if	by no means - by	one particular - one
at the present time - now	in his effort to - while, during, to	one time - once
as a method of - for	in most instances - usually, often	on a one-time basis - once
able to - can	in addition to - besides	one of the - one, a, an
as a means of - for	in a manner which - in a way	of all - usually drop this
a limited number of - most, some, few	in the beginning - first, at first	on an equal basis - equally
at the end of - after	in many instances - often, sometimes	of such - of
all these - these	is defined as - is	overall - general, complete, total
a number of - most, many, several	not the case - not so	period of time - period
and also - and, also	not the same - different	permits the- does, allows
as a result of - because	may possibly - may	point in time - time
appears to be - is		present time - currently, now
basically - usually a filler, omit this		referred to - called
by means of - by		regardless of - despite
		some of the - some

Cliche Words and Phrases
And finally . . . - use 'And' sparingly to start a sentence. at hand - here as to how much more - avoid can indeed dominate - avoid indeed in the case of - here in fact - avoid this in general - use this sparingly in itself- use this phrase sparingly. in the long run - further more and more - avoid this, try 'often', 'frequently'. on the basis of - using over and above - beyond wishful thinking - try want.

Redundant Words
end product - product
end result - result
past experience - experience
planning for the future - planning
point in time when - point when
the exact same - the same
their own difficulties - their difficulties
throughout the entire - throughout, in the entire
time period - period

Overstated and Pretentious Wording	
assist - help, aid	disseminate - distribute
accomplish - do	demonstrate - show, prove
acquire - get	determine - find, fit, decide
accommodate - fit	elect - choose, pick
achieve - do, get	estimation - estimate, opinion
ascertain - find out	furthermore - also, then
consequently - following, resulting	inasmuch as - since, as, because
changes necessitated - required	indicate - show
configuration - shape, form, pattern	moreover - besides, also
concept - idea	the foregone - the, this, these
demonstrate - show, prove	substantially - mostly, in essence
	whatsoever - at all

Vague Adverbs and Informal Colloquial Speech

Vague Adverbs - You should avoid using these.
actually
fairly
indeed
overly
quite
rather
relatively

Informal and Colloquial Speech
but that - that
identical to - identical with
likewise - and, also
length of time - time
relative to - about
so far as - as far as
some other - another
will have to be - must

APPENDIX C

GRAMMATIC IV ANALYSIS

The following pages show the results that Grammatic IV gave when fed the original and revised publication. The following table is a convenient summary of the work.

Document Summary Table				
Chapter	Statistic	Original Score	Revised Score	Improvements
1	Grade level: Reading Ease: Passive Voice	14 31 30 %	12 36 0 %	2 Grade levels 4 Points 30 Percent
2	Grade level: Reading Ease: Passive Voice	13 32 21 %	12 39 0 %	1 Grade level 7 Points 21 Percent
3	Grade level: Reading Ease: Passive Voice	12 43 35 %	10 52 2 %	2 Grade levels 9 Points 33 Percent
4	Grade level: Reading Ease: Passive Voice	15 32 23 %	9 54 0 %	6 Grade levels 22 Points 23 Percent
5	Grade level: Reading Ease: Passive Voice	13 34 24 %	12 37 0 %	1 Grade level 3 Points 24 Percent
6	Grade level: Reading Ease: Passive Voice	12 35 18 %	11 39 1 %	1 Grade level 4 Points 17 Percent
7	Grade level: Reading Ease: Passive Voice	11 46 39 %	10 53 0 %	1 Grade level 7 Points 39 Percent

(Continued on Next Page)

Document Summary Table (Continued)				
Chapter	Statistic	Original Score	Revised Score	Improvements
8	Grade level: Reading Ease: Passive Voice	11 53 27 %	9 59 0 %	2 Grade levels 6 Points 27 Percent
9	Grade level: Reading Ease: Passive Voice	12 48 35 %	10 52 0 %	2 Grade levels 4 Points 35 Percent
10	Grade level: Reading Ease: Passive Voice	10 49 22 %	8 62 0 %	2 Grade levels 13 Points 22 Percent
11	Grade level: Reading Ease: Passive Voice	12 41 21 %	11 45 1 %	1 Grade level 4 Points 20 Percent
12	Grade level: Reading Ease: Passive Voice	12 42 27 %	10 51 0 %	2 Grade levels 9 Points 27 Percent
13	Grade level: Reading Ease: Passive Voice	11 46 18 %	10 49 0 %	1 Grade level 3 Points 18 Percent
14	Grade level: Reading Ease: Passive Voice	12 44 30 %	11 46 0 %	1 Grade level 2 Points 30 Percent
15	Grade level: Reading Ease: Passive Voice	13 40 27 %	11 46 2 %	2 Grade levels 6 Points 25 Percent
16	Grade level: Reading Ease: Passive Voice	13 36 18 %	12 38 1 %	1 Grade level 2 Points 17 Percent
17	Grade level: Reading Ease: Passive Voice	12 40 21 %	10 46 1 %	2 Grade levels 6 Points 20 Percent

GRAMMATIC IV generated the following reports.

Original Publication -- Chapters One and Two.

```
    File  Statistics                                                   F1=Help
IMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM;
:                                                                              :
:   Document Summary for:  E:\chptr1.ori          Problems detected: 78        :
:                                                                              :
GDD Readability Statistics        Interpretation DDDDDDDDDDDDDDDDDDDDDDDDDDDDDD6
:   Grade level:            Difficult for most readers.                        :
:     14 (Flesch-Kincaid)                                                      :
:   Reading ease score:     This represents a level above the 11th grade.      :
:     31 (Flesch)                                                              :
:   Passive voice:          Writing may be difficult to read or ambiguous      :
:     30%                   for this writing style.                            :
:                                                                              :
:   Avg. sentence length:   Most readers could easily understand sentences     :
:     19.2 words            of this length.                                    :
:                                                                              :
:   Avg. word length:       Vocabulary may be too advanced for most readers.   :
:     1.85 syllables                                                           :
:                                                                              :
.   Avg. paragraph length:  Most readers could easily follow paragraphs of     :
:     3.4 sentences         this length.                                       :
:                                                                              :
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM<

                   C - Check another file      Q - Quit
```

```
    File  Statistics                                                   F1=Help
IMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM;
:                                                                              :
:   Document Summary for:  E:\chptr2.ori          Problems detected: 105       :
:                                                                              :
GDD Readability Statistics        Interpretation DDDDDDDDDDDDDDDDDDDDDDDDDDDDDD6
:   Grade level:            Difficult for most readers.                        :
:     13 (Flesch-Kincaid)                                                      :
:   Reading ease score:     This represents a level above the 11th grade.      :
:     32 (Flesch)                                                              :
:   Passive voice:          Writing may be difficult to read or ambiguous      :
:     21%                   for this writing style.                            :
:                                                                              :
:   Avg. sentence length:   Most readers could easily understand sentences     :
:     17.2 words            of this length.                                    :
:                                                                              :
:   Avg. word length:       Vocabulary may be too advanced for most readers.   :
:     1.86 syllables                                                           :
:                                                                              :
:   Avg. paragraph length:  Most readers could easily follow paragraphs of     :
:     2.1 sentences         this length.                                       :
:                                                                              :
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM<

                   C - Check another file      Q - Quit
```

```
   File  Statistics                                                F1=Help
```

Document Summary for: E:\chptr3.ori — Problems detected: 307

Readability Statistics	Interpretation
Grade level: 12 (Flesch-Kincaid)	Difficult for most readers.
Reading ease score: 43 (Flesch)	This represents a level above the 11th grade.
Passive voice: 35%	Writing may be difficult to read or ambiguous for this writing style.
Avg. sentence length: 18.3 words	Most readers could easily understand sentences of this length.
Avg. word length: 1.72 syllables	Vocabulary may be too advanced for most readers.
Avg. paragraph length: 2.9 sentences	Most readers could easily follow paragraphs of this length.

C - Check another file Q - Quit

```
   File  Statistics                                                F1=Help
```

Document Summary for: E:\chptr4.ori — Problems detected: 80

Readability Statistics	Interpretation
Grade level: 15 (Flesch-Kincaid)	Difficult for most readers.
Reading ease score: 32 (Flesch)	This represents a level above the 11th grade.
Passive voice: 23%	Writing may be difficult to read or ambiguous for this writing style.
Avg. sentence length: 23.0 words	Most readers could easily understand sentences of this length.
Avg. word length: 1.79 syllables	Vocabulary may be too advanced for most readers.
Avg. paragraph length: 2.6 sentences	Most readers could easily follow paragraphs of this length.

C - Check another file Q - Quit

```
   File  Statistics                                                F1=Help
```

Document Summary for: E:\chptr5.ori — Problems detected: 66

Readability Statistics	Interpretation
Grade level: 13 (Flesch-Kincaid)	Difficult for most readers.
Reading ease score: 34 (Flesch)	This represents a level above the 11th grade.
Passive voice: 24%	Writing may be difficult to read or ambiguous for this writing style.
Avg. sentence length: 18.9 words	Most readers could easily understand sentences of this length.
Avg. word length: 1.81 syllables	Vocabulary may be too advanced for most readers.
Avg. paragraph length: 2.0 sentences	Most readers could easily follow paragraphs of this length.

```
                C - Check another file      Q - Quit
```

```
   File  Statistics                                                F1=Help
```

Document Summary for: E:\chptr6.ori — Problems detected: 130

Readability Statistics	Interpretation
Grade level: 12 (Flesch-Kincaid)	Difficult for most readers.
Reading ease score: 35 (Flesch)	This represents a level above the 11th grade.
Passive voice: 18%	Writing may be difficult to read or ambiguous for this writing style.
Avg. sentence length: 14.7 words	Most readers could easily understand sentences of this length.
Avg. word length: 1.85 syllables	Vocabulary may be too advanced for most readers.
Avg. paragraph length: 3.1 sentences	Most readers could easily follow paragraphs of this length.

```
                C - Check another file      Q - Quit
```

```
    File  Statistics                                                F1=Help
```

Document Summary for: E:\chptr7.ori — Problems detected: 103

Readability Statistics	Interpretation
Grade level: 11 (Flesch-Kincaid)	Difficult for most readers. This represents a level above the 11th grade.
Reading ease score: 46 (Flesch)	
Passive voice: 39%	Writing may be difficult to read or ambiguous for this writing style.
Avg. sentence length: 16.9 words	Most readers could easily understand sentences of this length.
Avg. word length: 1.70 syllables	Vocabulary may be too advanced for most readers.
Avg. paragraph length: 3.6 sentences	Most readers could easily follow paragraphs of this length.

C - Check another file Q - Quit

```
    File  Statistics                                                F1=Help
```

Document Summary for: E:\chptr8.ori — Problems detected: 77

Readability Statistics	Interpretation
Grade level: 11 (Flesch-Kincaid)	Difficult for most readers. This represents a 6-10th grade level.
Reading ease score: 53 (Flesch)	
Passive voice: 27%	Writing may be difficult to read or ambiguous for this writing style.
Avg. sentence length: 20.6 words	Most readers could easily understand sentences of this length.
Avg. word length: 1.57 syllables	Most readers could understand the vocabulary used in this document, based on syllables per word.
Avg. paragraph length: 2.2 sentences	Most readers could easily follow paragraphs of this length.

C - Check another file Q - Quit

```
   File  Statistics                                                    F1=Help
```

Document Summary for: E:\chptr9.ori — Problems detected: 148

Readability Statistics	Interpretation
Grade level: 12 (Flesch-Kincaid)	Difficult for most readers.
Reading ease score: 48 (Flesch)	This represents a level above the 11th grade.
Passive voice: 35%	Writing may be difficult to read or ambiguous for this writing style.
Avg. sentence length: 20.9 words	Most readers could easily understand sentences of this length.
Avg. word length: 1.62 syllables	Most readers could understand the vocabulary used in this document, based on syllables per word.
Avg. paragraph length: 2.8 sentences	Most readers could easily follow paragraphs of this length.

```
                C - Check another file      Q - Quit
```

```
   File  Statistics                                                    F1=Help
```

Document Summary for: E:\chptr10.ori — Problems detected: 126

Readability Statistics	Interpretation
Grade level: 10 (Flesch-Kincaid)	Preferred level for most readers.
Reading ease score: 49 (Flesch)	This represents a level above the 11th grade.
Passive voice: 22%	Writing may be difficult to read or ambiguous for this writing style.
Avg. sentence length: 15.3 words	Most readers could easily understand sentences of this length.
Avg. word length: 1.68 syllables	Most readers could understand the vocabulary used in this document, based on syllables per word.
Avg. paragraph length: 2.5 sentences	Most readers could easily follow paragraphs of this length.

```
                C - Check another file      Q - Quit
```

```
   File  Statistics                                                F1=Help
```

```
Document Summary for:  E:\chptr11.ori          Problems detected: 118

Readability Statistics        Interpretation
  Grade level:              Difficult for most readers.
    12 (Flesch-Kincaid)
  Reading ease score:       This represents a level above the 11th grade.
    41 (Flesch)
  Passive voice:            Writing may be difficult to read or ambiguous
    21%                     for this writing style.

  Avg. sentence length:     Most readers could easily understand sentences
    19.0 words              of this length.

  Avg. word length:         Vocabulary may be too advanced for most readers.
    1.73 syllables

  Avg. paragraph length:    Most readers could easily follow paragraphs of
    2.1 sentences           this length.
```

```
                C - Check another file      Q - Quit
```

```
   File  Statistics                                                F1=Help
```

```
Document Summary for:  E:\chptr12.ori          Problems detected: 102

Readability Statistics        Interpretation
  Grade level:              Difficult for most readers.
    12 (Flesch-Kincaid)
  Reading ease score:       This represents a level above the 11th grade.
    42 (Flesch)
  Passive voice:            Writing may be difficult to read or ambiguous
    27%                     for this writing style.

  Avg. sentence length:     Most readers could easily understand sentences
    18.2 words              of this length.

  Avg. word length:         Vocabulary may be too advanced for most readers.
    1.73 syllables

  Avg. paragraph length:    Most readers could easily follow paragraphs of
    2.5 sentences           this length.
```

```
                C - Check another file      Q - Quit
```

```
   File  Statistics                                                F1=Help
```

```
   Document Summary for:  E:\chptr13.ori          Problems detected: 76

 Readability Statistics        Interpretation
   Grade level:              Difficult for most readers.
      11 (Flesch-Kincaid)
   Reading ease score:       This represents a level above the 11th grade.
      46 (Flesch)
   Passive voice:            Writing may be difficult to read or ambiguous
      18%                    for this writing style.

   Avg. sentence length:     Most readers could easily understand sentences
      16.1 words             of this length.

   Avg. word length:         Vocabulary may be too advanced for most readers.
      1.71 syllables

   Avg. paragraph length:    Most readers could easily follow paragraphs of
      2.5 sentences          this length.
```

```
                C - Check another file      Q - Quit
```

```
   File  Statistics                                                F1=Help
```

```
   Document Summary for:  E:\chptr14.ori          Problems detected: 54

 Readability Statistics        Interpretation
   Grade level:              Difficult for most readers.
      12 (Flesch-Kincaid)
   Reading ease score:       This represents a level above the 11th grade.
      44 (Flesch)
   Passive voice:            Writing may be difficult to read or ambiguous
      30%                    for this writing style.

   Avg. sentence length:     Most readers could easily understand sentences
      18.5 words             of this length.

   Avg. word length:         Vocabulary may be too advanced for most readers.
      1.70 syllables

   Avg. paragraph length:    Most readers could easily follow paragraphs of
      2.5 sentences          this length.
```

```
                C - Check another file      Q - Quit
```

```
   File  Statistics                                                  F1=Help
IMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM;
:                                                                            :
:   Document Summary for:  E:\chptr15.ori          Problems detected: 73     :
:                                                                            :
GDD Readability Statistics        Interpretation DDDDDDDDDDDDDDDDDDDDDDDDDDDDD6
:   Grade level:              Difficult for most readers.                    :
:      13 (Flesch-Kincaid)                                                   :
:   Reading ease score:       This represents a level above the 11th grade.  :
:      40 (Flesch)                                                           :
:   Passive voice:            Writing may be difficult to read or ambiguous  :
:      27%                    for this writing style.                        :
:                                                                            :
:   Avg. sentence length:     Most readers could easily understand sentences :
:      19.6 words             of this length.                                :
:                                                                            :
:   Avg. word length:         Vocabulary may be too advanced for most readers.:
:      1.74 syllables                                                        :
:                                                                            :
:   Avg. paragraph length:    Most readers could easily follow paragraphs of :
:      2.1 sentences          this length.                                   :
:                                                                            :
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM<

                C - Check another file      Q - Quit
```

```
   File  Statistics                                                  F1=Help
IMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM;
:                                                                            :
:   Document Summary for:  E:\chptr16.ori          Problems detected: 80     :
:                                                                            :
GDD Readability Statistics        Interpretation DDDDDDDDDDDDDDDDDDDDDDDDDDDDD6
:   Grade level:              Difficult for most readers.                    :
:      13 (Flesch-Kincaid)                                                   :
:   Reading ease score:       This represents a level above the 11th grade.  :
:      36 (Flesch)                                                           :
:   Passive voice:            Writing may be difficult to read or ambiguous  :
:      18%                    for this writing style.                        :
:                                                                            :
:   Avg. sentence length:     Most readers could easily understand sentences :
:      16.9 words             of this length.                                :
:                                                                            :
:   Avg. word length:         Vocabulary may be too advanced for most readers.:
:      1.82 syllables                                                        :
:                                                                            :
:   Avg. paragraph length:    Most readers could easily follow paragraphs of :
:      6.4 sentences          this length.                                   :
:                                                                            :
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM<

                C - Check another file      Q - Quit
```

File Statistics F1=Help

```
Document Summary for:  E:\chptr17.ori          Problems detected: 112

Readability Statistics        Interpretation
   Grade level:               Difficult for most readers.
      12 (Flesch-Kincaid)
   Reading ease score:        This represents a level above the 11th grade.
      40 (Flesch)
   Passive voice:             Writing may be difficult to read or ambiguous
      21%                     for this writing style.

   Avg. sentence length:      Most readers could easily understand sentences
      16.3 words              of this length.

   Avg. word length:          Vocabulary may be too advanced for most readers.
      1.77 syllables

   Avg. paragraph length:     Most readers could easily follow paragraphs of
      2.3 sentences           this length.
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Document Summary for: E:\cptr1.rev — Problems detected: 20

Readability Statistics	Interpretation
Grade level: 12 (Flesch-Kincaid)	Difficult for most readers.
Reading ease score: 36 (Flesch)	This represents a level above the 11th grade.
Passive voice: 0%	The amount of passive voice is within a reasonable range for this writing style.
Avg. sentence length: 14.8 words	Most readers could easily understand sentences of this length.
Avg. word length: 1.84 syllables	Vocabulary may be too advanced for most readers.
Avg. paragraph length: 3.0 sentences	Most readers could easily follow paragraphs of this length.

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Document Summary for: E:\cptr2.rev — Problems detected: 27

Readability Statistics	Interpretation
Grade level: 12 (Flesch-Kincaid)	Difficult for most readers.
Reading ease score: 39 (Flesch)	This represents a level above the 11th grade.
Passive voice: 0%	The amount of passive voice is within a reasonable range for this writing style.
Avg. sentence length: 14.8 words	Most readers could easily understand sentences of this length.
Avg. word length: 1.81 syllables	Vocabulary may be too advanced for most readers.
Avg. paragraph length: 2.5 sentences	Most readers could easily follow paragraphs of this length.

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Document Summary for: E:\chptr3.rev Problems detected: 164

Readability Statistics	Interpretation
Grade level: 10 (Flesch-Kincaid)	Preferred level for most readers.
Reading ease score: 52 (Flesch)	This represents a 6-10th grade level.
Passive voice: 2%	The amount of passive voice is within a reasonable range for this writing style.
Avg. sentence length: 14.8 words	Most readers could easily understand sentences of this length.
Avg. word length: 1.65 syllables	Most readers could understand the vocabulary used in this document, based on syllables per word.
Avg. paragraph length: 3.0 sentences	Most readers could easily follow paragraphs of this length.

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Document Summary for: E:\chptr4.rev Problems detected: 52

Readability Statistics	Interpretation
Grade level: 9 (Flesch-Kincaid)	Preferred level for most readers.
Reading ease score: 54 (Flesch)	This represents a 6-10th grade level.
Passive voice: 0%	The amount of passive voice is within a reasonable range for this writing style.
Avg. sentence length: 14.5 words	Most readers could easily understand sentences of this length.
Avg. word length: 1.63 syllables	Most readers could understand the vocabulary used in this document, based on syllables per word.
Avg. paragraph length: 2.5 sentences	Most readers could easily follow paragraphs of this length.

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:   Reading ease score:       This represents a level above the 11th grade.  :
:      37 (Flesch)                                                           :
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:      0%                     reasonable range for this writing style.       :
:                                                                            :
:   Avg. sentence length:     Most readers could easily understand sentences :
:      15.9 words             of this length.                                :
:                                                                            :
:   Avg. word length:         Vocabulary may be too advanced for most readers.:
:      1.82 syllables                                                        :
:                                                                            :
:   Avg. paragraph length:    Most readers could easily follow paragraphs of :
:      2.3 sentences          this length.                                   :
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GDD Readability Statistics        Interpretation DDDDDDDDDDDDDDDDDDDDDDDDDDDDD6
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:   Reading ease score:       This represents a level above the 11th grade.  :
:      39 (Flesch)                                                           :
:   Passive voice:            The amount of passive voice is within a        :
:      1%                     reasonable range for this writing style.       :
:                                                                            :
:   Avg. sentence length:     May indicate choppiness or lack of sentence    :
:      11.6 words             variation.  Try varying sentence length.       :
:                                                                            :
:   Avg. word length:         Vocabulary may be too advanced for most readers.:
:      1.84 syllables                                                        :
:                                                                            :
:   Avg. paragraph length:    Most readers could easily follow paragraphs of :
:      3.2 sentences          this length.                                   :
:                                                                            :
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Document Summary for:  E:\chptr7.rev          Problems detected: 45

Readability Statistics        Interpretation
Grade level:                  Preferred level for most readers.
   10 (Flesch-Kincaid)
Reading ease score:           This represents a 6-10th grade level.
   53 (Flesch)
Passive voice:                The amount of passive voice is within a
   0%                         reasonable range for this writing style.

Avg. sentence length:         Most readers could easily understand sentences
   16.1 words                 of this length.

Avg. word length:             Most readers could understand the vocabulary used
   1.82 syllables             in this document, based on syllables per word.

Avg. paragraph length:        Most readers could easily follow paragraphs of
   2.8 sentences              this length.
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   File  Statistics                                              F1=Help
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Document Summary for:  E:\chptr8.rev          Problems detected: 57

Readability Statistics        Interpretation
Grade level:                  Preferred level for most readers.
   9 (Flesch-Kincaid)
Reading ease score:           This represents a 6-10th grade level.
   59 (Flesch)
Passive voice:                The amount of passive voice is within a
   0%                         reasonable range for this writing style.

Avg. sentence length:         Most readers could easily understand sentences
   16.0 words                 of this length.

Avg. word length:             Most readers could understand the vocabulary used
   1.55 syllables             in this document, based on syllables per word.

Avg. paragraph length:        Most readers could easily follow paragraphs of
   2.8 sentences              this length.
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Document Summary for: E:\cptr9.rev — Problems detected: 37

Readability Statistics	Interpretation
Grade level: 10 (Flesch-Kincaid)	Preferred level for most readers.
Reading ease score: 52 (Flesch)	This represents a 6-10th grade level.
Passive voice: 0%	The amount of passive voice is within a reasonable range for this writing style.
Avg. sentence length: 17.1 words	Most readers could easily understand sentences of this length.
Avg. word length: 1.62 syllables	Most readers could understand the vocabulary used in this document, based on syllables per word.
Avg. paragraph length: 3.2 sentences	Most readers could easily follow paragraphs of this length.

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Document Summary for: E:\cptr10.rev — Problems detected: 95

Readability Statistics	Interpretation
Grade level: 8 (Flesch-Kincaid)	Preferred level for most readers.
Reading ease score: 62 (Flesch)	This represents a 6-10th grade level.
Passive voice: 0%	The amount of passive voice is within a reasonable range for this writing style.
Avg. sentence length: 13.3 words	Most readers could easily understand sentences of this length.
Avg. word length: 1.55 syllables	Most readers could understand the vocabulary used in this document, based on syllables per word.
Avg. paragraph length: 2.5 sentences	Most readers could easily follow paragraphs of this length.

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Document Summary for:  E:\cptr11.rev          Problems detected: 128

Readability Statistics        Interpretation
   Grade level:            Difficult for most readers.
      11 (Flesch-Kincaid)
   Reading ease score:     This represents a level above the 11th grade.
      45 (Flesch)
   Passive voice:          The amount of passive voice is within a
      1%                   reasonable range for this writing style.

   Avg. sentence length:   Most readers could easily understand sentences
      17.0 words           of this length.

   Avg. word length:       Vocabulary may be too advanced for most readers.
      1.71 syllables

   Avg. paragraph length:  Most readers could easily follow paragraphs of
      2.1 sentences        this length.
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   File  Statistics                                                F1=Help
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Document Summary for:  E:\cptr12.rev          Problems detected: 47

Readability Statistics        Interpretation
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      10 (Flesch-Kincaid)
   Reading ease score:     This represents a 6-10th grade level.
      51 (Flesch)
   Passive voice:          The amount of passive voice is within a
      0%                   reasonable range for this writing style.

   Avg. sentence length:   Most readers could easily understand sentences
      15.5 words           of this length.

   Avg. word length:       Most readers could understand the vocabulary used
      1.65 syllables       in this document, based on syllables per word.

   Avg. paragraph length:  Most readers could easily follow paragraphs of
      2.6 sentences        this length.
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Document Summary for: E:\cptr13.rev — Problems detected: 24

Readability Statistics	Interpretation
Grade level: 10 (Flesch-Kincaid)	Preferred level for most readers.
Reading ease score: 49 (Flesch)	This represents a level above the 11th grade.
Passive voice: 0%	The amount of passive voice is within a reasonable range for this writing style.
Avg. sentence length: 15.2 words	Most readers could easily understand sentences of this length.
Avg. word length: 1.68 syllables	Most readers could understand the vocabulary used in this document, based on syllables per word.
Avg. paragraph length: 3.3 sentences	Most readers could easily follow paragraphs of this length.

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Document Summary for: E:\cptr14.rev — Problems detected: 22

Readability Statistics	Interpretation
Grade level: 11 (Flesch-Kincaid)	Difficult for most readers.
Reading ease score: 46 (Flesch)	This represents a level above the 11th grade.
Passive voice: 0%	The amount of passive voice is within a reasonable range for this writing style.
Avg. sentence length: 15.7 words	Most readers could easily understand sentences of this length.
Avg. word length: 1.71 syllables	Vocabulary may be too advanced for most readers.
Avg. paragraph length: 3.9 sentences	Most readers could easily follow paragraphs of this length.

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                C - Check another file      Q - Quit
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   File  Statistics                                                    F1=Help
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Document Summary for: E:\chptr15.rev — Problems detected: 33

Readability Statistics	Interpretation
Grade level: 11 (Flesch-Kincaid)	Difficult for most readers.
Reading ease score: 46 (Flesch)	This represents a level above the 11th grade.
Passive voice: 2%	The amount of passive voice is within a reasonable range for this writing style.
Avg. sentence length: 17.1 words	Most readers could easily understand sentences of this length.
Avg. word length: 1.70 syllables	Vocabulary may be too advanced for most readers.
Avg. paragraph length: 3.0 sentences	Most readers could easily follow paragraphs of this length.

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Document Summary for: E:\chptr16.rev — Problems detected: 54

Readability Statistics	Interpretation
Grade level: 12 (Flesch-Kincaid)	Difficult for most readers.
Reading ease score: 38 (Flesch)	This represents a level above the 11th grade.
Passive voice: 1%	The amount of passive voice is within a reasonable range for this writing style.
Avg. sentence length: 16.4 words	Most readers could easily understand sentences of this length.
Avg. word length: 1.80 syllables	Vocabulary may be too advanced for most readers.
Avg. paragraph length: 6.4 sentences	Most readers could easily follow paragraphs of this length.

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:                                                                            :
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:      10 (Flesch-Kincaid)                                                   :
:   Reading ease score:       This represents a level above the 11th grade.  :
:      46 (Flesch)                                                           :
:   Passive voice:            The amount of passive voice is within a        :
:      1%                     reasonable range for this writing style.       :
:                                                                            :
:   Avg. sentence length:     Most readers could easily understand sentences :
:      13.5 words             of this length.                                :
:                                                                            :
:   Avg. word length:         Vocabulary may be too advanced for most readers.:
:      1.74 syllables                                                        :
:                                                                            :
:   Avg. paragraph length:    Most readers could easily follow paragraphs of :
:      2.4 sentences          this length.                                   :
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APPENDIX D

USER'S PREFERENCE STUDY

STEP 1. This study sampled both sections of IS3170, before the students received their economic analysis guide. The students received a sample of the original guide and a sample of the current or previous revision (see the following pages). They were to show their preference.

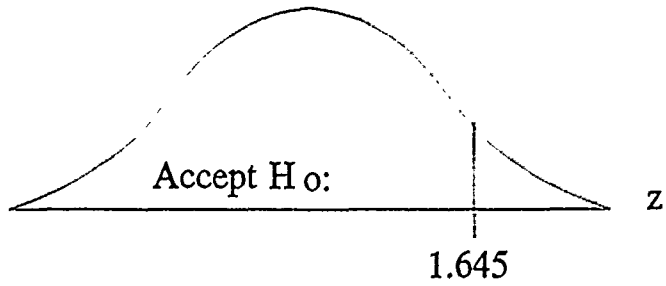
The students turned in 60 samples. Out of this sample, 20 indicated no preference, 26 preferred the revised publication, and 14 preferred the original publication. Although nearly two of every three students with a preference chose the revised manual, is this meaningful?

STEP 2. Determining a test for statistical significance was the next step. The Z distribution provides this test.

Test H_0: $\rho \leq .5$ versus H_1: $\rho > .5$

for $n = 40$ & $x = 26$. Use $\alpha = .05$

STEP 3. Next, the sampling selected the region where we accept H_0 and note the sample lacks significance, and the area of significance. An α of .05 corresponds to a Z of 1.645.

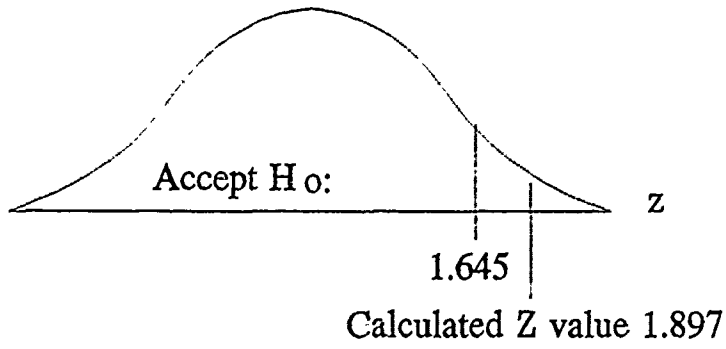


STEP 4. The next step is to calculate the sample's Z value. The calculations are:

$$Z = \frac{26 - (40 \div 2)}{\sqrt{(40 * .5) * (1 - .5)}}$$

$$= 1.897$$

STEP 5. The calculated value of Z equals 1.897. The next step is to see where this value falls out on the distribution.



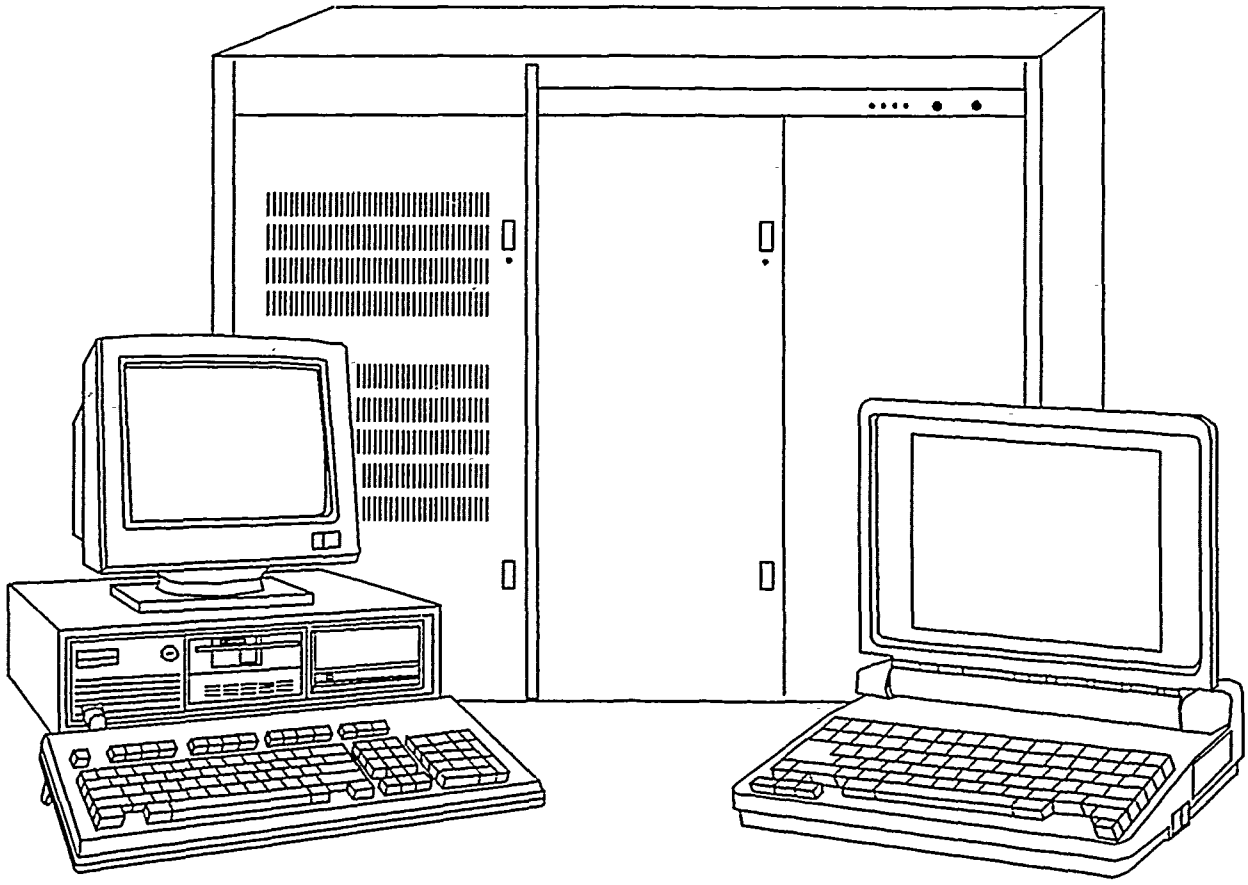
Because the calculated value of Z is greater than 1.645, the study rejects the null hypothesis, H_0. This means that we accept that the sample is statistically significant. We can accept the sample's assertion. Of people with a preference, two of every three people prefer the revised manual.

APPENDIX E

REVISED ECONOMIC ANALYSIS PROCEDURES FOR ADP

This appendix is the revised publication. Because it is in book form, this study did not continue the thesis page numbering into the document. The page numbering continues on the distribution list.

Revised Economic Analysis Procedures for ADP



William J. Haga

and

Robert G. Lang

TABLE OF CONTENTS

APPENDICES

PART I - INTRODUCTION

CHAPTER 1

THE IDEA OF ECONOMIC ANALYSIS

INTRODUCTION

For personnel who have little or no experience with economic analyses, this book establishes a routine to perform economic analysis. Supervisors and functional managers who must initiate or review economic analyses also will find this book of value. You can easily apply the techniques described here to all types of investments. Still, this book deals with the economic problems of choice in the acquisition of information technology.

ECONOMIC ANALYSIS DEFINED

Economic analysis is a systematic approach to evaluating alternative projects. The technique keys on the premise that alternative ways of reaching an objective exist and each alternative requires certain resources and produces certain results. Economic analysis relates costs, benefits, and uncertainties of each alternative to find the most cost effective means of meeting an objective. It is not a search for the cheapest solution despite effectiveness.

You must incorporate *three basic principles in the economic analysis*:

1. You must *investigate all reasonable alternative methods* of satisfying a given objective.

2. You must *consider the absolute value of both current and future expenditures* for all the alternatives.

3. Because of the "time value of money," you *must understand* not only how much a proposal will cost, but also *when you will make the expenditures and discount their values.* To include this consideration in the analysis you express each alternative's life cycle costs in terms of its present value.

USES OF ECONOMIC ANALYSIS

Generally, you use economic analysis two ways: First, to assess the economic consequences of a past decision. Second, to assess the economic consequences of a future decision. As Figure 1-1 shows, the distinction lies in the relationship of the analysis to the planning and decision process.

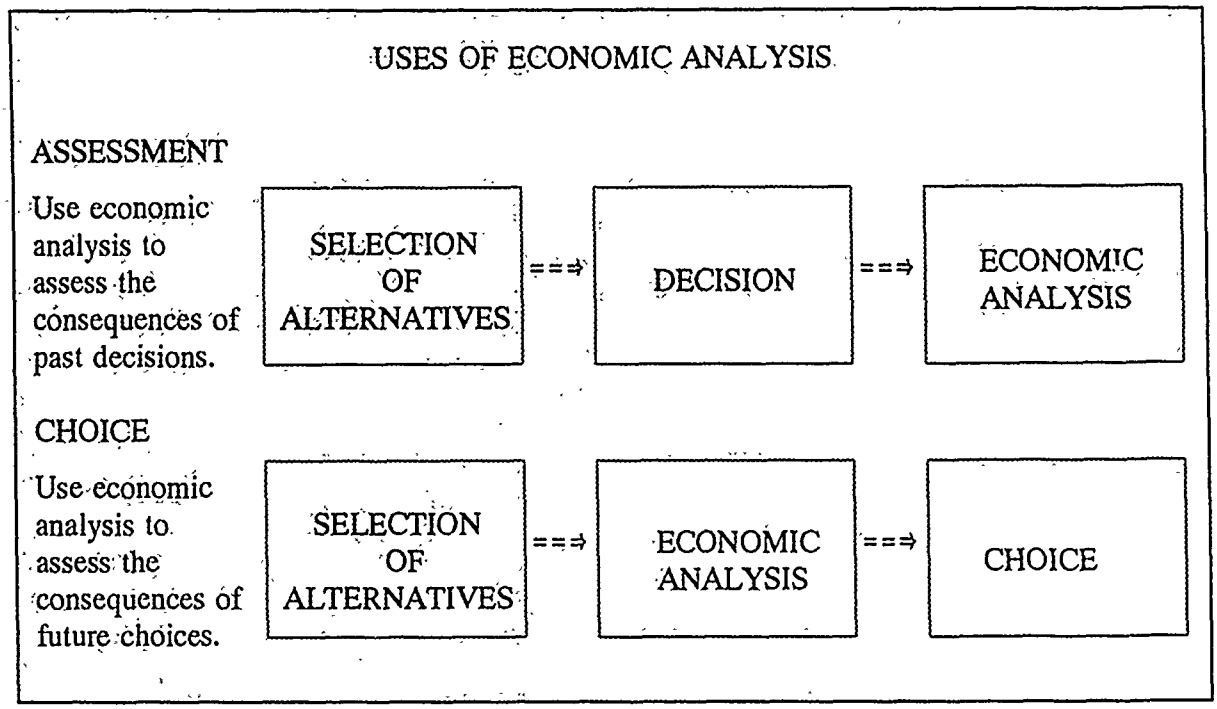


Figure 1-1

The first use, assessment, assumes that you already have made a decision. You can use the results to decide a future course of action. For example, suppose you run a data processing installation. To recoup your costs, you decide to implement a charge back system. You perform an economic analysis to assess all costs associated with operating the installation. Using this information, you could then figure out an equitable means of charging your customers.

The second use, choice, assumes that you will make a decision based on the economic consequences of alternatives. For example, suppose that the space in your computer room is inadequate. You must choose among building a new space, renovating the old space, buying or renting another facility, or remaining with the status quo. Here, you do not make a decision until you evaluate the costs and benefits of each alternative.

ECONOMIC ANALYSIS AND THE BUDGET

An economic analysis seldom leads to cost estimates consistent with your budget. This inconsistency occurs for several reasons. First, a budget is a spending plan reflecting actual out of pocket expenses you expect to incur. An economic analysis considers not only out of pocket costs, but also opportunity costs, such as resources already on hand that have alternative uses. Second, many budgets reflect past spending trends in an unstructured environment. Economic analysis develops future cash flows and projected costs in a structured environment. Third, you always include fringe benefits in an economic analysis. Finally, an economic analysis states future costs and benefits in terms of their present value.

LIMITATIONS

Economic analysis is subject to many limitations. First, economic analysis does not normally establish priorities among various goals and objectives. Instead, economic analysis merely seeks to find the most cost effective means to satisfy a *given* objective.

Second, an economic analysis is not a process for choosing the preferred means of meeting an objective. Economic analysis is only an *input* to the decision making process. You must weigh the results of the economic analysis against other factors, such as safety, health, morale, environmental impact, political considerations, and national priorities. Economic analysis is not a substitute for sound judgement. By systematically quantifying what you can quantify, economic analysis lets you focus your judgement on the areas vital to your decision.

Finally, an economic analysis cannot provide results that are more valid than the input data. Judicious formulation of assumptions and careful estimation of costs and benefits are critical to the economic analysis process.

Yet, no matter how much care you exercise during these stages, you cannot eliminate uncertainty. Economic analysis necessarily involves assumptions, projections, and estimates of *future* events whose outcomes you do not know with certainty until they occur.

WHEN YOU DO NOT NEED ECONOMIC ANALYSIS

A complete economic analysis of even a small, limited problem can become involved and expensive. Therefore, you do not need an economic analysis when you can show that its benefits are not commensurate with the effort involved.

Example 1-1

Suppose that you take five working days to do a simple economic analysis and you earn $1000 per week for your work. You want to purchase a text formatting system whose total costs are $999. Should you perform an economic analysis?

Solution

No! The economic analysis costs more than the project. If you decide to purchase the system after doing an analysis, the total cost is $1999. If an analysis shows that the system is not a sound investment, you spent $1000 to save $999.

Department of Defense (DOD) Directives prescribing alternative replacement criteria or equipment tradeoff standards and legislative action and higher authorities can exempt you from doing an economic analysis.

CHAPTER 2

THE ECONOMIC ANALYSIS PROCESS

INTRODUCTION

The Economic Analysis Process is a systematic, six step procedure for comparing alternative means to meet an objective. You must document the results of your analysis in a written report. In the report, you describe each step and identify pertinent background information, the scope of your analysis, the methodology you used, and your conclusions and recommendations. Appendix A provides a suggested format for this report. Figure 2-1 shows this process.

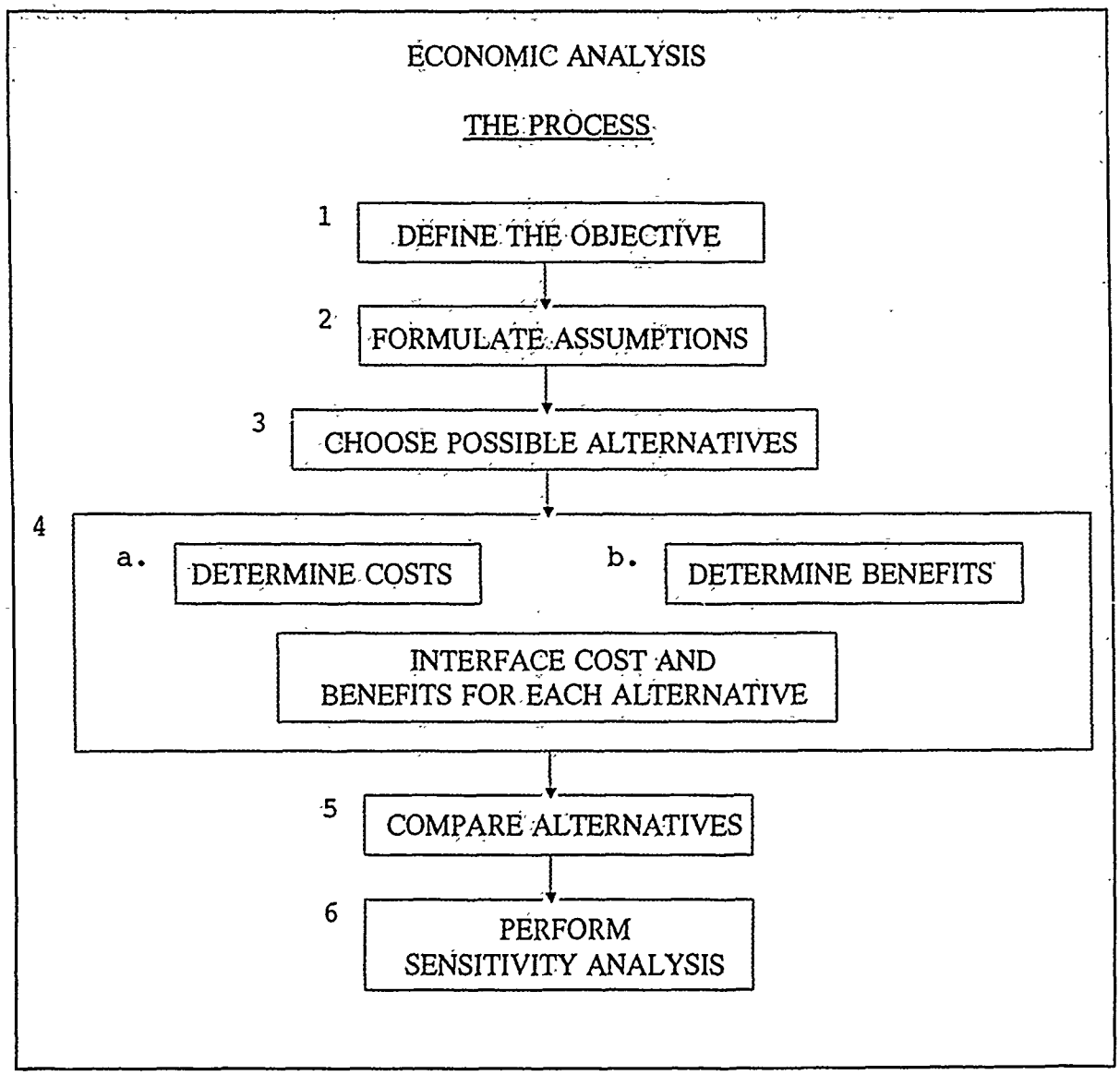


Figure 2-1

DEFINING THE OBJECTIVE

The most important step in the economic analysis process is defining the objective. Most simply stated, an objective is a fixed standard of accomplishment. You should state an objective in terms of a mission or goal. The actual wording of the objective is critical and should reflect a totally unbiased point of view concerning the method of solving the problem. For example, if your goal is to provide a secure, climate controlled work space for electronic equipment with access to utilities, users, and data, state your objective as such. Do not say that your objective is to *construct* an automated data processing (ADP) center. This might rule out modification of existing facilities or rental of space.

Examples of economic analysis objectives include:

1. To process the Mid-Western region ADP work load.

2. To improve ADP service at the Naval Air Engineering Center while reducing the cost of ADP.

3. To free your main frame computer of non-command and control applications and provide a 25% surge capacity for crisis and exercise operations.

4. To examine the monetary impact of installing a System-370 at Newport, Rhode Island.

5. To examine the cost of establishing a local area network (LAN) in Norfolk, Virginia.

FORMULATE ASSUMPTIONS

In all phases of government activity, you operate in an environment of restrictions on what you can and cannot do. For purposes of analyses, you present these restrictions as assumptions and constraints.

Assumptions are explicit statements describing the present and future environment that is the base of the economic analysis. Each analysis, no matter how formal or informal, will have assumptions. You simply do not know enough with certainty to avoid making assumptions, particularly when dealing with the future. The purpose of the assumption is not to limit the analysis, but to reduce complex problems to manageable proportions. *You must carefully choose and identify all assumptions so that you can realize the basis under which you will eventually develop and evaluate the alternatives.*

Four rules to observe in making assumptions are:

1. Don't confuse assumptions with facts. Make assumptions only when required to bridge gaps in essential information you cannot obtain, even after diligent research.

2. Be certain the assumptions are realistic and not mere platitudes or pipe dreams.

3. State assumptions positively, using the word "will." For example, "The ADP system *will* have an economic life of eight years." "We *will* have military construction (MILCON) funds in the next fiscal year."

4. Find out if your conclusions remain valid even if you remove an assumption. If yes, then eliminate the assumption. It is not a requirement that you must meet.

Examples of assumptions include the estimated future workload, the estimated useful life of an asset, and the period over which you will compare alternatives.

Constraints are factors external to the relevant environment that limit alternatives to problem solutions. They may be time related, as with a fixed deadline; physical, as with a fixed amount of space; financial, as with a fixed or limited amount of resources; or institutional, as with organizational or defense policy and regulations. Whatever particular characteristics they have, these external constraints or barriers are beyond your control. Thus, they provide boundary limitations for alternative solutions to a particular problem.

You must be careful when making assumptions and constraints. An alternative is feasible only when it satisfies all the restrictions you assume. Unduly restrictive assumptions and constraints bias your analysis and precludes your investigation of feasible alternatives. Conversely, failure to consider pertinent assumptions and constraints can cause you to recommend a technically or structurally infeasible alternative.

CHOOSE POSSIBLE ALTERNATIVES

Next, you must identify all feasible means of meeting the objective. You must present a comprehensive discussion of the techniques and operational characteristics of each alternative. As a minimum, this discussion should include a description of the method of operation, type of equipment, volume of workload, and any other factors unique to the system. In developing alternatives, you ensure that each alternative addresses the same requirements and that all alternatives satisfy the minimum requirements of acceptability. Later evaluation will reflect the differences in acceptability or effectiveness.

Rarely does an objective have only one alternative. For example, in ADP problems, usually, you can consider buy versus lease, manual versus automated, mainframe versus PC, and repair versus replace. Thus, the discussion of alternatives must show that you explored all reasonable options.

Your search for alternative solutions to an existing problem should not overlook the current system. The current system represents the alternative that seeks to identify the level of costs and benefits that would accrue without changing the present method of operation. If a current system exists and it is feasible, then this system will serve as a baseline with which to compare new alternatives. Note, if you have no current feasible current system, there is no baseline.

Other alternatives that you should consider when evaluating an ADP proposal are:

1. Modifying the current system by modifying existing ADP resources, hiring additional personnel, among others.

2. Getting the capability from a Navy Regional Data Center (NARDAC) or from another government agency through resource sharing.

3. Contracting with a nongovernmental source to provide the required capability.

Each method of problem solution has its own mix of resources. While one method requires a multitude of personnel, another may require a large capital investment. Only your creativity and thoroughness limit the number of alternatives.

Sometimes, when you're preparing an economic analysis, you must select alternatives that keep within certain constraints such as work force, facilities, or funding limitations. You must take care to avoid the imposition of arbitrary constraints that in turn unduly limit the number of alternatives available. Such limitation of alternatives will simplify the analysis, but they do so by excluding other, possibly better, alternatives. Keep in mind that you should not regard as final the list of alternatives that you compiled earlier in the study. As the analysis proceeds, you may devise new and better alternatives, while you eliminate those not feasible within the constraints.

DETERMINING AND RELATING COSTS AND BENEFITS

In actual practice, the step that usually is the most difficult and time consuming is estimating the costs and benefits of each alternative. Most simply stated, costs are inputs, whereas benefits are outputs.

You figure out costs and benefits for the entire useful life of a project. You must make appropriate year by year estimates of costs you will incur or benefits you will receive. The difference between the costs of alternatives is most important to you. Omit from the analysis costs that do not change under any alternative and note this exclusion in your assumptions.

Benefits usually are not as easy to identify as costs. Still, you should quantify them whenever possible. You should identify, evaluate, and quantify intangible benefits such as "increased morale" or "increased safety."

You must look into all possible alternatives to ensure you obtain the best available cost and benefit estimates. Because the acceptance of the analysis depends upon the credibility of the estimates, you must document all sources and derivations of cost and benefit data.

COMPARE ALTERNATIVES

Once you figure out costs and benefits for each alternative, you can evaluate one proposal against another. Usually, you can compare and rank the alternatives according to one of three general criteria. Table 2-1 shows the criteria and the cost/benefit relationship with which it conforms.

TABLE 2-1

GENERAL RANKING CRITERIA

1. Least costs for a given level of effectiveness	Unequal costs/equal benefits
2. Most effectiveness for a given constraint	Equal costs/unequal benefits
3. Largest ratio of effectiveness to costs	Unequal costs/unequal benefits

If you have alternatives with equal benefits and costs, factors other than economic factors determine your selection.

Table 2-2 summarizes the comparison of alternatives.

TABLE 2-2

COMPARISON OF ALTERNATIVES

Costs	Benefits	Basis for Recommendation
Equal	Unequal	Most benefits
Unequal	Equal	Least cost
Unequal	Unequal	Greatest benefit to cost ratio
Equal	Equal	Not an economic analysis

Note that the first two bases for recommendation are special cases of the third. That is, if all alternatives have the same costs but unequal benefits, then the alternative with the greatest measurable benefits will have the greatest benefit/cost ratio (BCR). If all alternatives offer comparable benefits but have unequal cost, then the least cost alternative will have the greatest benefit to cost ratio.

Techniques to evaluate and compare alternatives include:

1. Present Value Analysis. This brings all future cost and benefits back to their present worth. You use this when the economic life of a project is more than three years.

2. Uniform Annual Cost. This is a cost oriented approach to evaluate alternatives with unequal economic lives.

3. Saving/Investment Ratio. This is the relationship between future cost savings and the investment needed to obtain those savings. Because saving is a necessary ingredient, you use this if, and only if, you have a status quo alternative.

4. Discounted Payback. This determines the period that the accumulated present value of the savings require to offset the total present value cost of an alternative. You can use this if, and only if, you have a status quo alternative.

5. Break-Even Analysis. This focuses on the value of a variable (break-even point) where two alternatives are equal. This seeks to find your point of indifference.

6. Benefit/Cost Ratio. This shows the relationship between output and cost. Use this technique to assess alternatives having unequal cost and unequal benefits.

SENSITIVITY ANALYSIS

You must examine uncertainty in your economic analysis to figure out its influence on your recommendation. To test how sensitive your analysis is to uncertainty, you evaluate factors having key relationships to the results of the analysis. You explore the extent and magnitude of their impact.

In performing sensitivity analysis, you figure out how the results change with changes in system parameters or basic assumptions. If a change in a parameter or assumption causes a proportionally greater change in the analysis, then it is *sensitive* to that parameter or assumption.

PART II - COST/BENEFIT IDENTIFICATION

CHAPTER 3

GENERAL COST CATEGORIES

INTRODUCTION

When you perform an economic analysis, you will encounter various costs. Some costs are pertinent to your evaluation, other costs have no place in it. You must identify and evaluate all costs for each alternative over its entire life cycle.

LIFE CYCLE COSTS

Life cycle costing follows the theme that your decision to undertake a particular course of action must account for its total cost, not just its acquisition and start up cost. You must account for the cost of developing, procuring, and operating a system. Generally, you find three costs within the life cycle:

1. Research and Development Costs primarily are the costs associated with the development of a new system.

2. Investment Costs are costs beyond the development phase to introduce a new system.

3. Operations Costs are recurring costs of operating, supporting, and maintaining a system.

Figure 3-1 shows the timing, if not the magnitude, of these costs during the life cycle.

LIFE CYCLE COSTS

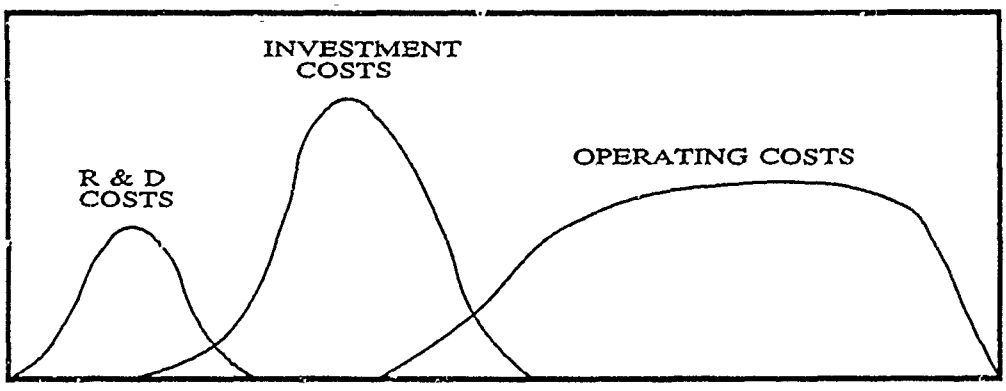


Figure 3-1

OPPORTUNITY COST

Implicit in the discussion of costs is the idea of alternative use. When you use limited resources for a particular purpose, you give up benefits that another alternative could have produced with the same resources. Economists refer to the value of that forsaken alternative as the *opportunity cost* of employing the resources. You incur opportunity costs when you divert resources already on hand from their current use to another project.

Example 3-1

Your boss tasks you to form a team to design a new product. With great confidence in your ability, he tells you to select whoever you need for the project. Still, your boss also wants you to tell him what the opportunity costs are for your dream team. You select the following: Worker A, who recently finished a project and now hangs around the water cooler looking for something to do. Worker B, who, like worker A, needs a project but receives twice as much pay as worker A. Worker C, who now works on contract work earning your firm $100 per day. Worker D supervises worker C and earns $150 per day for the company. What is the opportunity cost?

Solution

Workers A and B have zero opportunity costs. To employ them on your project, you do not forego any benefit. To employ worker C, you will forgo $100 per day in revenue (benefits). For worker D, you will forgo $150 per day. The opportunity cost for your team is $250 per day.

SUNK COSTS

The principle of life cycle costing applies only to those costs you will incur after you choose an alternative. Life cycle costing only applies to those cash flows that the choice can affect. Costs that you will incur no matter which alternative you choose do not belong in your analysis. They are sunk costs.

Sunk costs include costs already incurred. Your decision concerning future alternatives cannot change costs incurred in the past. Obligations that the law requires you to meet also are sunk costs. When you perform an economic analysis, past costs and mandatory obligations are irrelevant. Do not include them in the analysis.

Example 3-2

Suppose you evaluate alternative ways of replacing a piece of Automatic Data Processing (ADP) hardware at your data processing center. Last year, you entered into a 10 year lease for the building where you house your equipment. You pay $5,000 per month for this lease. You know that to lease another suitable building will cost you the same amount. You paid $10,000 to upgrade the building's electrical system and $20,000 to upgrade the building's heating and cooling system. How do you handle the electrical, heating and cooling upgrade, and the lease cost in an analysis of ADP hardware alternatives?

Solution

The costs of the electrical, heating, and cooling upgrades are sunk costs. Do not include them. Whether you stay in the old building or move to a another building, you must pay $5,000 per month for rent. Since this cost remains the same no matter which alternative you select, do not include it in your analysis.

Example 3-3

Two years ago, the research and development branch of your company developed a computer that would operate under water at a depth of up to 2,000 feet. While the research and development cost $500,000, the actual construction of the computer, including costs of set up, totals $1,000. Today, a customer asked you to quote a price for ten of these computers. What is the lowest price you should quote?

Solution

The lowest price you should quote is $1,000. The research and development costs are sunk. Whether you sell no underwater computer or a thousand underwater computers, you already paid for the research and development cost. You cannot get that money back no matter what you do. It is a sunk cost.

Despite the fact that you should not include sunk costs as part of your cost analysis, some people still prefer to have a narrative account of such costs to provide additional background information. Avoid this temptation. Sunk costs have no place in an economic analysis.

DETERMINING THE COST OF RESOURCES

Before you can determine the cost of a particular resource, you must first decide if your organization already has the resource available.

EXTERNAL RESOURCES

External resources are any raw materials, labor, equipment, or any inputs to a process that you get from an external source. If you do not have a resource in-house, then the cost of the resource is the acquisition or purchase price.

IN-HOUSE RESOURCES

In determining the value of resources that you already have in-house, you must figure out if your organization currently uses the resource, plans to use it, or if it is surplus.

If the resource is available in-house and your organization already uses it, or plans to use it, for you to employ it in a new use would mean removing the resource from its present or planned use. The cost of using an in-house, already employed, resource is the cost of replacing it, providing a substitute for it, or the costs of the losses you incur by denying it to another project. That is the resource's opportunity cost.

If your organization currently does not use or plan to use the resource, then you could employ it in a new alternative without denying its use to another in-house purpose. At this point, you must set a fair value for the surplus resource. If your organization could sell the resource, then the cost of this unused resource is its market or salvage value. If you cannot sell, dispose of, or reuse the resource, its cost is zero.

Example 3-4

Your boss wants to assign several system analysts who are already on the staff to an automated data system design effort. They may design a system that uses existing excess mainframe capacity or their design may require new hardware and facility space that your company planned to use for another project. Do these actions have an economic cost? If so, how could you figure out the current market value?

Solution

All these actions have an economic cost. You forego the use of the resource for another project once you take each action. You base the current market value on the replacement cost of the resource; that is, the price you must pay if you buy an identical resource in the market place.

Example 3-5

Your company decides to upgrade its existing computer system. The new central processing unit (CPU) is a top-of-the-line time sharing system. Yet, because of a mistake at the computer manufacturing plant, the manufacturer painted the computer black, instead of blue. So, they offer it to you at half price. This excites your boss. Additionally, you determined you can recycle some obsolete CP/M equipment and daisy wheel printers. For the past two years, you stored this equipment in a broom closet. Despite your best efforts to sell it at any price, you found no buyers. The new system will require four additional operators. Does this decision have related economic costs?

Solution

Since this project involves new equipment and personnel, it has economic cost. You determine the cost of new resources at their acquisition price. This is the wages and benefits you pay the four operators. For the new CPU, this is the discounted price. Since the CP/M equipment and printers were surplus without salvage value, they have zero cost.

JOINTLY USED RESOURCE

You figure out the cost of resources that two projects jointly use based on how costs will increase if you employ the resource in an alternative project. If the alternative eliminates the joint function, you must figure out how costs will change with the usage of the resource.

NONRECURRING AND RECURRING COSTS

In an economic analysis, you view costs as non-recurring and recurring.

1. Non-recurring Costs are one-time costs. They include system development, activation and start up costs. Some occur during the operating life cycle. Nonrecurring costs include payments for investments and the rental costs of equipment, real estate, and nonrecurring services. Nonrecurring cost include:

a. Research and Development (R&D) Costs. These are costs incurred prior to the first staffing and equipping of a project. R&D pays to design the system, its components and perform development testing. R&D costs are insensitive to the number of units that you will buy or the length of time you will use the system. R&D costs end once an alternative is ready to use.

b. Investment Costs. These are the costs to get equipment and real property; one-time service, operation, and maintenance (start-up) costs; and other one-time costs. Investment costs are a function of the number of units you buy. The more units you buy, the higher the investment cost. If you know when you will incur the costs, you may spread investment costs over several years. Investment costs include:

(1) Land acquisition or easement.

(2) New construction.

(3) Rehabilitation or modification.

(4) Equipment (ADP and telecommunications).

(5) Software purchases.

(6) System development. Including: (a) Development of functional requirements. (b) System design, analysis, programming. (c) Testing and conversion.

(7) Relocation costs.

(8) One-time personnel costs such as recruitment, travel, relocation, separation, and training.

c. Working Capital is the amount of liquid funds and current assets on hand or on order. Generally, working capital is some form of inventory of consumable or similar resources held in readiness for use or in stock. An increase to working capital requires additional funding. Decreases to working capital reduce the requirement for funding.

d. Value of Existing Assets Employed is the value of assets already on hand that *you* plan to use with the new project. You include their value in the investment cost *only* when you currently use the existing assets, plan to use them for an alternative project, or plan to sell the assets. Because you would use or sell these assets, include them at their fair market value and document the basis of this value.

e. Terminal or Residual Value. Often, you can impute value to assets that you no longer use. This value can be either terminal or residual. *Terminal value*, a special case of residual value, is the expected value of buildings, equipment or other assets after their economic lives. You reduce the life-cycle cost of a particular alternative by its terminal or residual value. *You may compute residual value of assets at any time.* Residual value may or may not coincide with terminal value. You apply terminal or residual value to existing assets as you replace them, and to new assets as you get them.

If a proposed project eliminated the requirement for existing assets or property, you will need to find out if they have terminal value. If you redistribute this property to another federal or state agency without direct reimbursement, while that agency benefits, you have no terminal value because you have no reimbursement or cash flow. If you have a documented alternative use for an asset you transfer to another agency, then and only then, can you reduce your investment cost by the fair market value. If you sell the assets, the proceeds to your organization set the terminal value.

The terminal value of a new asset is its estimated value after its economic life. Such factors as the probability of continued need for the facility (for Government or private use), appreciation, and depreciation (physical and functional) offset future terminal value. Apply the estimated future value of the asset after its economic life.

What you will do with an asset is probably the most important criterion for determining its terminal or residual value. You need to know if you will scrap the asset, sell it, or reuse it. Will you continue to use it? Each of these could call for a different value.

(1) Scrap Value of an Asset. If you will scrap an asset, then its value is its scrap value less costs of dismantling and selling the scrap. Often, scrap values are so small and occur so far in the future that they may have no significant impact on a decision. In such cases, you need not include the terminal value in the analysis. Still, if you expect a significant scrap value, then you should include it. Remember to document how you derived the value.

(2) Sale of an Asset. If you are going to sell an asset, the proceeds benefit the Government because the Treasury Department accounts for it as Miscellaneous Receipts. The value you report is the actual sale price less the cost of the sale.

(3) Reuse of an Asset. If you are going to redistribute property to another Federal Agency, that agency benefits, though you receive no reimbursement for the property. You figure out the asset's value by its worth in the market less costs attributed to redistribution.

(4) Continued Use of an Asset. Often, you will need to use an asset for an extended period far into the future. When this occurs, the automatic replacement of assets and repeating cash flows will result in a repetitive cycle of expenditures. You can handle a single project involving multiple assets with different lives two ways.

The first way is to let the economic life of the dominant asset prevail, replacing assets with shorter lives as necessary. The second way uses the shortest economic life and imputes residual value to the asset with the longer life. Here, you use a pro-rata amount to figure out the residual value. Chapter 7, example 7-6 and 7-7, show this.

Example 3-6

An alternative for expanding an ongoing mission involves acquisition of both buildings and equipment. The new building costs $20 million and has an economic life of 30 years. The equipment costs $5 million and has an economic life of 10 years. How do you handle the long term effects of the residual value?

Solution

Since the mission is ongoing and will continue to use the same type of equipment, you can use a 30 year life, replacing the equipment every 10 years. Or you can use a 10-year life, showing residual value for the building. Using the second method, you pro-rate the value of the building to compute the residual value. Thus, the residual value of the building after 10 years is 20/30 of the original cost, or $13.3 million.

2. Recurring Costs, usually called operation cost, are costs you incur regularly, throughout the project. They sustain an alternative throughout its life cycle and provide routine support and maintenance. They vary directly with the number of units in a program and the length of time you operate, support and maintain such units. Recurring costs include:

a. Personnel Costs. This is civilian and military costs, employee benefits, and other personnel related costs.

(1) Civilian Personnel Costs. You base civilian personnel costs on current annual salaries as defined by the General Schedule and Wage Board pay rates. Where you identify specific skills with an operation or process, use the middle step of the actual grade in computing wage costs.

(a) Adjustment for Fringe Benefits. Civil service employees cost the government more than their salaries. This is because they draw fringe benefits. These benefits include the Government's contribution for civilian retirement, disability, health and life insurance and where applicable, social security programs. Customarily, you express the value of fringe benefits as a percentage of annual base pay. The Office of Management and Budget (OMB) Circular A-76 gives guidance for developing fringe benefits. The current prescribed rate is 26% and has the following factors:

Retirement and disability (for employees under Civil Service Retirement).	20.4%
Health and Life Insurance	3.7%
Other benefits including work disability unemployment programs, bonuses and awards	1.9%

For civilian employees (normally temporary employees) who are not under the Civil Service Retirement System, the Social Security (FICA) cost factor you apply to salary or wage cost is the actual employer contribution rate for the employees involved. When estimating FICA cost, you must ensure that you apply the FICA rate only to wages and salaries subject to the tax. Obtain information regarding FICA tax rates and maximum wages and salaries to which they apply from your personnel office.

Example 3-7

Using the 26% fringe benefit factor, what is the total cost for an employee earning an annual base salary of $14,000.

Solution

You compute the total personnel costs as:

$14,000 + ($14,000 x .26) = $17,640

(b) Adjustment for Leave. When a requirement specifies a set number for civilian personnel services, this number already includes compensation for sick, holiday and annual leave. Yet, when a requirement specifies certain man-hours of work, you use a leave factor to increase the base hours to allow for leave. This is necessary to account for employees on leave. The OMB prescribed leave rate is 18%.

Example 3-8

A proposed job requires 400 hours of labor at $15 per hour. Considering the fringe benefit factor and leave allowance, what is the total personnel cost for the project?

Solution

First, use the 18% leave allowance to adjust the projected man-hours. This is:

400 hours + (400 hours x .18) = 472 hours.

Then, multiply this amount by $15 per hour to get the adjusted costs:

472 hours x $15 per hour = $7080.

Next, use the 26% fringe benefit factor to adjust the total personnel costs:

$7080 + ($7080 x .26) = $8921.

(2) Military Personnel Costs. You base military personnel costs on the current composite standard military rates. Navy Comptroller (NAVCOMPT) Manual, paragraph 035750 identifies these rates. The composite rates provide for the basic, incentive and special pay, and certain expenses and allowances included in the active forces military personnel appropriations.

(a) Adjustment for Fringe Benefits. You must adjust the composite rate to include retirement and other personnel costs, such as medical and commissary benefits, that the composite rate does not include. Paragraph 036760 of the NAVCOMPT Manual provides percentage factors for retirement and other costs. The current rate is 25% for officers, 40% for enlisted personnel and has the following factors:

Retirement Entitlement Accrual rate for both officers and enlisted personnel	17%
Accrual Rate for Other Personnel Costs	
for officers	8%
for enlisted personnel	23%

(b) Adjustment for Leave. You apply leave adjustments for military personnel as you would civilian leave. The prescribed NAVCOMPT Manual factor is 20%.

(3) Other Personnel Related Costs. You should include in other personnel related costs such as travel, per diem, and periodic training.

b. Operating Costs. This category includes operating costs other than labor such as:

(1) Equipment rental/maintenance

(2) Space rental/maintenance

(3) Materials and supplies

(4) Utilities

(5) Communications

(6) Commercial services

c. Overhead Costs. You classify some costs as overhead because you cannot associate them with specific units of production. Accounting, legal, fire and police protection, custodial services and general administrative costs are overhead. When estimating overhead costs for an alternative, you must take care to itemize only the overhead costs that will change because of the investment proposed. For example, an alternative that significantly decrease personnel needed to provide a service may have no effect on the size of the security force.

PRESENTATION OF COST DATA

Your analysis should contain a description of each cost element and how you derived that figure. For example, if you computed personnel requirements on specific production rates, you should identify those production rates and the numbers and grades of people needed.

Once you have discussed all costs, you should present them in a way that allows the decision maker to review the data easily. You should consider the costs on a cash-flow basis for each yea , identified by category; nonrecurring or recurring. Figure 3-2 shows a sample format for presenting costs.

UNDISCOUNTED COSTS ALTERNATIVE No.___				
COST ELEMENT	FY 0	FY 1	FY 2	FY n
1. Non-recurring Cost a. ADP Equipment (ADPE) b. Site Construction c. System Development d. Telecommunications e. Travel				
2. Recurring Cost a. ADPE Maintenance b. Personnel c. Space Rental d. Supplies e. Telecommunications				
TOTAL COST				

Figure 3-2

CHAPTER 4

INFLATION

INTRODUCTION

To make an economic analysis a useful decision making tool, you must accurately estimate future costs and benefits. Prices that persistently and appreciably rise over time complicate projecting costs with precision. Fortunately, the economic analysis process and the standard 10% discount rate implicitly resolve the issue of inflation. Thus you do not need to be too concerned about the effect of inflation in your analysis. Besides, explicitly introducing inflation into your analysis usually does not affect in the final ranking of your alternatives. Therefore, the remainder of this chapter explains some problems that inflation causes and how the economic analysis process and you handle these problems.

TERMS TO KNOW

Before you can manipulate inflation and account for its effects in your analysis, you need to understand a few of the most basic terms.

1. Inflation is a general rising level of prices. This does not mean that a rising price for a single product is inflation. Nor do all prices necessarily rise during periods of inflation. In fact, a major problem with inflation is its unpredictability.

2. Changes in Demand are shifts in the desirability of a product in the marketplace. Given a set supply, an increase in demand for a product results in a shortage in the market, leading to higher prices. This does not represent inflation.

3. Changes in Supply are shifts in the quantity of a product in the marketplace. Given a set demand, a decrease in supply for a product results in a shortage in the market, leading to higher prices. This does not represent inflation.

4. Changes in Price are shifts of the supply-demand equilibrium point, as noted above in 2 and 3. This shift does not represent inflation.

5. Base Year Dollars are the value of dollars after you adjust them for inflation.

6. Current Dollars are costs and monetary benefits reflecting the actual amount you pay including any amount due to future price changes.

7. Base Year Prices are prices in effect at the beginning of an analysis and prices after you adjust them for inflation.

PROBLEMS OF INFLATION

You may readily associate several problems with inflation. Perhaps you note that things cost more today than they did years ago. Maybe you see that a dollar simply doesn't buy as much as it use to. Whether this is a real problem depends on several things. Does your budget automatically adjusts itself to reflect inflation? Do you have to figure out the rate of inflation and then request more money? Do you have a fixed budget?

If your budget adjusts itself to the inflation rate, then inflation is moot. For example, given that this year's rate of inflation is 10 percent, your budget automatically will include a 10 percent adjustment for inflation. While prices rise, you have more money to buy these goods.

Still, if you must figure out the rate of inflation and then request an adjustment, or if you have a fixed budget, you encounter another aspect of inflation. That is, while today's prices are higher and a dollar doesn't get as much as before, you don't know how high future prices will rise or how little a future dollar will buy.

This uncertainty complicates financial planning and economic analysis. Determining the rate of inflation and projecting the increase in prices and decrease in buying power would eliminate some of your uncertainty and complications.

Example 4-1

This year you have $100 in your budget to purchase mechanical pencils that cost $1 each. Normally, you buy 100 pencils. Over the course of the year, the inflation rate is 10 percent. Assume your budget adjusts itself for inflation and that pencils also keep up with inflation. How much money will next year's budget have for pencils and how many fewer pencils can you purchase? If you need 100 pencils next year, what other purchase will you reduce to have money to buy the pencils?

Solution

Since your budget automatically adjusts itself for inflation, and inflation was 10 percent, your budget will have 10 more dollars slated to purchase pencils. Thus, your new pencil budget is $110. If pencils kept up with inflation, they will cost 10 percent more, or $1.10 each. Thus, you can buy exactly 100 pencils, the same as the previous year. You forego nothing.

TREATMENT OF INFLATION IN COMPUTATIONS

The accurate treatment of inflation requires a two phased approach. Within the Department of Defense and Department of the Navy, DOD Instruction (DODI) 7041.3 and Secretary of the Navy (SECNAVINST) 7000.14B require this treatment of inflation in your analyses.

1. Do the analyses in terms of constant dollars. Make all estimates of costs and savings during the project life in terms of base year prices. This requires that you assume a rate of inflation.

a. Change cost projections to reflect only real changes in costs due to changes in amounts of services and improvements.

b. Change cost projections due to changing economies of scale due to an increase or decrease in the quantity of goods and services.

2. Find the present value of the cash flows. Chapter 8 discusses this in detail.

a. Avoid overestimating and double counting for the effects of inflation. Consider such factors as labor agreements and contracts that may include provisions for inflation, productivity and quantity changes, and the extent of material already on hand or obligated under fixed price contracts.

b. Whenever practicable, estimates will include forecasts of changes in price levels based on specific data applicable to a given acquisition. As part of the analysis, include the source of the inflation factors and the rates used.

c. Identify the estimates of inflation by fiscal year. Take particular care when including inflation in cost estimates for more than four years beyond the budget year. Forecasting future national economic conditions and factors for inflation involves uncertainty and are subject to considerable change.

The requirement to perform your analysis using constant dollars promotes consistency in your comparison of alternatives. As Chapter 9 discusses, the standard 10 percent discount factor implicitly escalates your cost estimates to reflect inflation. Thus, your economic analysis, at the 10 percent rate, should suffice. Again, introducing inflation factors into your analysis usually has little effect in the final ranking of your alternatives.

The following four step process shows how you can explicitly account for inflation within your analysis and proves how inflation does not change its outcome.

STEP 1 **Raise out-year costs to NOMINAL levels by expected inflation rate, I.**

Example 4-2

Assume an expected inflation rate of 5% that you call rate I. Then I = .05. Raise each out-year cost figure by 5%.

Year 0 costs do not get raised.
Year 1 costs are multiplied by 1.05
Year 2 costs are multiplied by $(1.05)^2$
Year 3 costs are multiplied by $(1.05)^3$
Year n costs are multiplied by $(1.05)^n$

Out years:	0	1	2	3
Uninflated costs:		1000	1000	1000
Inflation factor:	1	1.05	1.102	1.158
Inflated costs:	1000	1050	1102	1158

STEP 2 **Calculate nominal discount rate, D.**

Example 4-3

The nominal rate D includes the DOD discount rate of 10% (which we call R) plus inflation at rate I.

$$D = (1 + R)(1 + I) - 1$$

Example 4-4

Assume a DOD 10% rate combined with I, the 5% inflation rate.

$$D = (1.1)(1.05) - 1$$
$$D = (1.155) - 1$$
$$D = 15.5\%$$

STEP 3 **Plug D into the discount factor calculation.**

Discount factor = $(1 + D)^{-n}$

Example 4-5

Year 0 discount factor is $(1.155)^{-0} = 1$
Year 1 discount factor is $(1.155)^{-1} = .866$
Year 2 discount factor is $(1.155)^{-2} = .750$
Year 3 discount factor is $(1.155)^{-3} = .649$

STEP 4 **Combine nominal out-year inflation of costs with nominal rate of PV calculation.**

Basic discount: 10%. Projected inflation rate: 5%. Discount rate with inflation: 15.5%

Out years:	0	1	2	3
Uninflated costs:	1000	1000	1000	1000
Inflation factor:	1	1.05	1.102	1.158
Inflated costs:	1000	1050	1102	1158
Year-end discount factor:	1	.866	.750	.649
Present Value (PV) of	1000	909	826	751
costs:	1000	1909	2736	3487
Cumulative PV of costs:				
	$3,487			
PV of project:				

We have inflated out-year costs and calculated their PV with an inflation-adjusted discount factor. Compare that project PV value with the project PV you calculate for the same out-year costs without inflation.

Out years:	0	1	2	3
Projected costs:	1000	1000	1000	1000
Year-end discount factor:	1	.909	.826	.751
PV of costs:	1000	909	826	751
Cumulative PV of costs:	1000	1909	2736	3487
PV of project:	$3,487			

Voila! The PVs of both projects = $3,487. Calculations for expected inflation do not change the comparative projects' PVs. Accounting for inflation affects the increased out-year costs and the adjustment to the discount rate by the same percentage.

NOTE: If you used the mid-year discount factors instead of year-end factors, the PVs for the two projects would have been close but different.

SUMMARY

Does this mean you can ignore inflation in economic analysis? Yes. Still, make sure that you are consistent. If you ignore inflation in out-year costs, then do not adjust for inflation in your discount rate. If you do take account of inflation in out-year costs, then you must adjust for inflation in your discount rate.

Which should you do? Using real values and a real discount rate is usually better. Typically, your data on real cost increases is more accurate than your data on an expected rate of inflation. Predicted inflation rates, even by experts, often are wide of the mark.

Remember that all projected increases in out-year costs are not inflationary. For example, you out-year costs for labor that rise as a result of a wage contract settlement. The settlement, itself, may reflect local shortages of skilled people such as programmers.

Nonetheless, you would use the same discounting calculations. If the wage settlement raised labor costs by 7%, you would boost projected out-year labor cost accordingly. But, do not add a 7% premium to the DOD 10% discount rate. The reason: The 7% rise is a real increase. You adjust the DOD rate only when you are dealing with costs caused by inflation.

Suppose that, as part of an economic analysis, you receive cost data that shows out-year increases. Nothing tells you whether these increases are nominal (due to all prices in the economy rising) or real (due to supply and demand in a specific market). The source of the data may not know. You must make a judgment call. Yet, quick-and-dirty way to distinguish nominal changes from real ones exist. You can compare the annual percentage change in the out-year costs to the current annual percentage change in the Consumer Price Index (CPI).

If projected out-year costs rise at a rate close to the current CPI, you are looking at nominal (inflation-driven) changes. If the cost estimates are rising at a rate that is obviously different from the CPI then you can assume that inflation does not drive them. They are real changes.

CHAPTER 5

COST-ESTIMATING TECHNIQUES

INTRODUCTION

The adequacy or success of costing efforts primarily depends on your ability to establish relationships between the attributes and the elements of a proposal. That is, the relationship between the requirements of an alternative and the costs of these requirements. Cost estimating techniques depend upon such factors as the amount and detail of available data and the time and resources available to develop the cost estimate. This chapter discusses four cost estimating techniques: industrial engineering, parametric cost estimating, analogy, and Delphi estimating. To use these procedures, the level of effort and knowledge you need ranges from intuition to extreme detail.

INDUSTRIAL ENGINEERING METHOD

The industrial engineering method consolidates estimates from various separate work segments into a total project estimate. You may call this the "bottom up" process. It involves the separation of the total product (whether hardware or software) into simple parts for which you can establish detailed estimates. For example, the estimated cost of producing a new model "widget," requiring inputs from ten separate divisions, could be a summation of ten separate detailed estimates. Each estimates could be a composite of several other estimates.

You use one or more of the following to develop the detailed estimate for each work area:

1. Examination of historical data for similar items.

2. Reviewing current operations (using industrial engineering techniques such as work measurement, time and motion studies, sampling) and establishing new standards.

3. Engineering simulation of operations required to produce the item.

The result is the consolidation of the individual estimates into a total projected cost for the alternative.

An advantage of this method is that it separates the parts of the system on which little data are available and permit them to receive special treatment. The industrial engineering approach can result in extremely detailed and complete estimates of alternative costs. The industrial engineering method is the best method for estimating costs, where detailed data exists.

PARAMETRIC COST ESTIMATING METHOD

When you don't have enough data to use the industrial engineering approach, you may use the parametric cost estimating method. This method uses an object of known or estimated value to draw conclusions about the cost of another. The results of a parametric estimate depend on you. You must establish relationships between the parameters of the known object and its cost and the alternative's parameters and its cost.

This method focuses on what a proposal should do. The yield or benefit of the proposal forms the basis, or "parameters," for the cost estimates. Once you set the basis, you seek a relationship between the parameters and their costs. Usually, you form the relationships from historical data. If you use a single experience for data, your extrapolation to the proposal may be questionable. The data foundation firms up as your experience with similar systems increases.

Example 5-1

Suppose you look at buying a new house. Among your requirements for the house are:

Number of bedrooms (2, 3, 4 or more).

Number of baths (1, 1-1/2, 2, 2-1/2 or more).

Number of dens (0 or 1).

Number of finished family rooms (0 or 1).

Capacity of the garage (0, 1, or 2 cars).

Size of property lot (in acres).

Age of the house (in years).

Solution

Assume that you know the selling price for a house with any particular combination of these parameters, for example, the expected selling price of the house you currently occupy. You may estimate prices for other parameter mixes (similar houses) compared to this baseline (where you live, now).

While experience forms the bases for parametric estimates, you include costs due to problems inherent in system development. To resolve questions regarding unanticipated delays due to technical problems, redefined requirements, and midstream changes, you include these expenses in the historical data.

The primary limitation of parametric costing lies in the cost data that are available. Also, as the variation of new systems from previous systems increases, the credibility of the estimate decreases. Parametric cost estimating is the preferred procedure to use in deriving a cost estimate at the earliest stages of development. At this time, you can only base the system cost on expected physical and performance characteristics and their relationship to costs.

ANALOGY METHOD

When you have no qualified cost analysts and little historical data, the entire effort becomes an application of judgment. A special method of judgment is the use of analogies. An analogy is a direct comparison with similar, historical alternatives. A major caution with this process is that it is essentially a judgment process, requiring expertise and intuitive reasoning. Although this is a widely used method of estimating costs, it is not the most accurate.

There are two types of analogies: similar products and similar ideas. Using commercial aircraft costs to estimate the cost of military aircraft is a similar product analogy. Using aircraft costs to estimate missile costs is a similar idea analogy.

DELPHI METHOD

The Delphi method is a way of using expert opinion to arrive at a forecast or estimate. This subjects the views of individual experts to the criticism of others while avoiding face to face confrontation. This provides anonymity of opinions and arguments in defense of these opinions.

In one version of this technique, you replace direct debate with the exchange of information and opinion through a carefully designed sequence of questionnaires. You ask the participants to give not only their opinions but reasons for these opinions. At each successive interrogation you give them new and refined information as opinion feedback. You derive the feedback from the consensus over earlier parts of the program. This continues until additional progress toward a consensus is negligible. You then document the conflicting views.

The disadvantage of this technique is that it is cumbersome. Several weeks may elapse before the participants return their questionnaires or you can poll them. The amount of material you must process for each respondent for each round may be considerable. Because of the lapse of time the respondent may have difficulty reproducing earlier reasoning. Finally, those who are running the process have difficulty digesting and collating a formidable amount of material.

CHAPTER 6

BENEFIT QUANTIFICATION

INTRODUCTION

Benefits are the outputs you expect from costs incurred. In this usage, benefits are synonymous with results, effectiveness, utility, or performance. Because costs relate to inputs, not outputs, ***you do not consider cost reduction as a benefit.*** Benefit analysis presents a comprehensive, meaningful, and orderly display of expected returns, for each alternative. Benefits are more difficult to quantify than costs. This is because some benefits seem intangible. Some benefits have no simple common denominator such as dollars. If no common denominator is available, rank the benefits according to a hierarchy of values so that you can make a more rational choice.

Conduct a benefit analysis with a basic three step method:

1. Find, list, and define the relevant benefits.

2. Identify the sources of information.

3. Devise a system for measuring the benefits.

Besides benefits, include and quantify information concerning any negative aspects of alternatives. Such information could be the environmental, social, personal, and legal impact of the alternative. This information is important and may be a determining factor in deciding between possible investment alternatives.

STEP 1. FIND, LIST, AND DEFINE RELEVANT BENEFITS

This step involves naming the benefits for each alternative, whether you think them quantifiable or not. List all benefits which may shed light on the economic analysis alternatives. Eventually, you may discard some of them while others may become evident later. Nonetheless, give a full description of each benefit.

You may place the benefits expected of any alternative into various categories depending upon the kind of program, system, operation, or organization you are analyzing. The terminology you use for these categories is generally descriptive of the benefits included. The following is a guide to benefit categories you can use. It is not all inclusive. Instead, it illustrates some categories you could apply. They are:

1. Production. This is the number of commodities or items produced for each alternative. For example, number of meals served or components manufactured. You could state this in comparable time periods for the economic analysis.

2. Productivity. This is the number of items produced per man-hour.

3. Operating Efficiency. This is the rate at which the system consumes resources to get its output. For example, gallons per mile or copies per kilowatt hour.

4. Reliability. This is the system's probable failure rate. Useful measures may be mean-time-between-failure, service calls per year, or percent refusals per warehouse request.

5. Accuracy. This is the system's probable error rate. Useful measures may be errors per operating period, such as errors per card punched, errors per hundred records, errors per 100 hours of operation time.

6. Maintenance and Control. Did the system developers do adequate human engineering? Can adequately trained workers effectively use the system? When the system fails, is it difficult to repair because of poor accessibility? You could base useful measures on the average number of man-hours necessary for repairs over a given period, "downtime," or the work force required to control and maintain the system.

7. Manageability. Will implementing the system increase or decrease supervision or inspection time? Useful measures may be man-days, the difference in the kind of personnel or the availability of the type of personnel needed.

8. Integration. How will future changes in the system, such as modification of existing facilities or equipment, technical data requirements, initial personnel training, or warehouse space for raw goods or parts storage affect the workload and product of the organization? Will data from your previous system be compatible with the new system? What about programs developed for your previous system? What about supplies such as printer ribbons, paper, cards, and ink?

9. Availability of Equipment and Supplies. This is when you can deliver or implement the alternatives. You need to consider proposed output schedules and lead time for spare parts delivery, among others.

10. Service Life. This is how long the proposed system will affect the organization's workload or output. Remember to consider obsolescence?

11. Quality. Does an alternative provide a better quality product or service? Can you grade quality? If not, can you describe the improvement? What is the impact of varied quality?

12. Acceptability. Will the alternative interfere with the operation of parallel organizations or the operation or prerogatives of higher echelon organizations.

13. Environmental. Consider the environmental aspects of each alternative. What are current legislative requirements?

14. Economic. Consider employment benefits, DOD small business obligations, economically depressed area relationships, legislative requirements.

15. Morale. Will the alternative affect employee morale? Can you measure this as a reduction in sick leave days?

16. Safety. Will the alternative change the expected number of accidents or other hazards involved?

17. Security. Does it include security? Will this alternative require more precautions? More guards? Are thefts more likely?

Table 6-1 is an example of one analyst's initial listing of benefits. In this example, the analyst compared contracting a computer programming requirement to an established programming firm vice establishing a new in-house capability.

TABLE 6-1

EXAMPLE BENEFITS LIST

CONTRACT	IN-HOUSE
1. Fewer programming errors.	1. Quick debugging.
2. No training required.	2. Shorter turnaround time.
3. Known costs.	3. Easier communications.
4. Fewer personnel problems.	4. Provides training capability.
5. No equipment maintenance effort nor logistic support.	5. Decreased transmittal effort.
6. No costs if product does not meet the specification.	6. Improved management control.
7. Greater capability to manage varying work.	7. Immediate availability once established.
8. Avoid difficulties of recruiting during a programmer shortage.	8. Increased understanding of agency problems.
9. Increased experience and capacity for future expanded effort.	9. Greater ability to change the direction of the mission.

STEP 2. IDENTIFY SOURCES OF INFORMATION

For each benefit listed, identify:

1. The source of your information.

2. The form of the information.

3. If gathering the information is feasible, how can you gather it? Note the source of your information of both quantifiable benefits and those that seem unquantifiable.

STEP 3. DEVISE A SYSTEM FOR MEASURING BENEFITS

The third step is to devise a method to measure the output of each alternative. Such measurement can vary from precise quantities of physical output for the more tangible benefits to general narrative descriptions for intangibles outputs.

QUANTIFIABLE OUTPUT MEASURES

An economic analysis is most effective when you can define output in terms of physical yield. Each analysis will possess its own measure of effectiveness. In fact, an analysis may contain several different measures. For example, you could state reduced pollution in some quantifiable terms, such as gallons of effluence per hour. You might state decreased procurement lead time in days or in changes in inventory levels. In citing increased safety as a benefit, you could state the number of employees exposed to the dangers for each proposed alternative.

If you cannot precisely quantify the benefits, you might establish a relationship among the alternatives. You may express the benefits of one alternative as an index and relate the benefits of another alternative to that index.

As quantification of benefits becomes less feasible, you must rank the alternatives on a more subjective basis. This may consist of simple numerical listing in order of preference, with the alternative's position in the list not suggesting any particular level of benefits. Or you may use a verbal scale depicting the alternatives by using adjectives to show their relationships as excellent, good, or poor. These measurements are useful but not as precise as objective measurements.

NON-QUANTIFIABLE OUTPUT MEASURES

Despite your best efforts to develop quantitative measures of benefits, you sometimes face a problem that simply does not lend itself to easy quantification. Certain projects may provide only intangible benefits such as improved morale or better community relations. Although they are more difficult to assess, you should document and include these benefits in your analysis.

In these instances, use written, qualitative, benefit descriptions and the following guidance:

1. Identify all benefits attendant to each considered alternative. Give complete details.

2. Identify benefits common in kind but not in extent or degree among alternatives. Explain differences in detail.

3. Avoid platitudes. All prospective projects should support your mission. Do not restate this. Platitudinous statements cloud the decision making environment.

BENEFIT ANALYSIS PITFALLS

Some consider benefit quantification to be the weakest area in most economic analyses. To strengthen your analysis, avoid the most common pitfalls.

First, *do not confuse benefits and cost savings.* This error has a history of occurrence in ADP analyses. ADP people seem to think of their systems as a cost cutting asset. Cost savings is the difference in cost between alternatives. You reflect cost savings in the differential cost of alternatives and you may use it as a basis for decision between alternatives. Do not confuse cost savings with the output, product, or benefit of alternatives. Cost savings do not belong on the benefit side of the equation.

Benefits should reflect an organization's basic mission. The benefit or output of a system must support that mission. Accordingly, if cost savings were a benefit, then cost savings would be the reason for the existence of a system. How could you save the greatest cost of the system? *Eliminate the entire system*! Clearly, you must find the benefit in the product or service of the ADP system.

Another common, possibly deliberate, error is the "equal benefits" escape clause. One way of avoiding the problem of benefit measurement is to assume that benefits are equal and use least cost analysis. To establish equal benefits, you must be indifferent to the benefits of the alternatives.

If you are not indifferent, because the alternatives offer significantly different benefits, the least cost recommendation also fails to support itself.

For example, an analysis is faulty because it always recommends a modified or rebuilt system. It never recommends the development of a new system. If two alternatives offer equal benefits in terms of production rate, reliability, and responsiveness, the analysis is proper in recommending a modified or rebuilt system. If you can show that the new system offers a significant upgrade of capabilities, the least cost criterion is at fault. Use of the unequal cost/equal benefit criteria would enable you to identify the increased capability and the cost of the increase. Then, you evaluate increased cost against increased capability.

Another error is to use spurious measures of benefits. In searching for something to count, measure, or record, you may measure ancillary or independent activities because they have a tangible, easily identified product. For example, you may measure the "productivity" of the night shift workers based on CPU utilization or the "effectiveness" of a programmer based on number of lines of code produced.

Spurious measures are dangerous for several reasons. First, they do not necessarily measure the output you needed to measure. Second, once you highlight and use other activities as a performance measure, they can dominate your analysis. Third, once your workers realize how you grade them, they work to increase their score based on the spurious measure.

Another error is the omission of quality control. An unequivocal description or a set of specifications ensures that you do not increase productivity or decrease costs at the expense of quality and usefulness. For example, make an inferior product with fewer inputs.

The final error is quantification at any cost. Valid methods to measure almost all benefits exist, if you can justify the resources required for the task. Quantification is useful. But, you should seek it within the parameters of resources, validity, and accuracy. Inaccurate quantified measures can do more harm than good and may lead to poor decisions.

PART III - INVESTMENT CONCEPTS

CHAPTER 7

ECONOMIC LIFE AND PROJECT LIFE

INTRODUCTION

Chapter One defined economic analysis as a decision tool. A fundamental decision you personally or managerially make each day is whether to spend more money now and less tomorrow or less today and more tomorrow. A rational choice means that you must decide how far into the future to extend the expenditure. You must set the appropriate period of the economic analysis. Once you do this, you can develop cost streams for each alternative.

ECONOMIC LIFE

Economic life is the reasonable period over which you expect a project to accrue the savings or benefits. Three factors ultimately govern economic life:

1. The Mission Life is the period over which you anticipate a need for the asset or program. For example, a college freshman decides to purchase a personal computer to use for assignments at school. He anticipates that he will need the computer only during his remaining time in school. Thus, the mission life of the computer is four years.

2. The Physical Life is the period during which a facility or piece of equipment is available for use before it wears out in a physical sense. The physical life of an asset may vary depending upon usage, manufacturing quality, and the age of the asset when you first place it into production. For example, the college freshman compared the prices of new and used computers. According to a computer magazine he read, the internal components of a PC should last eight to ten years, given normal use. Thus, a new computer has a physical life of eight to ten years, while a used computer would have the same, less its previous ownership.

3. The Technological Life is the period you can use an asset before improved technology makes the asset obsolete. A computer remains technologically viable if you can enter and retrieve data from it in a usable form, provide required maintenance, and use it productively. As the use of key punch cards and batch systems show, the ability to interface with a computer often lingers on long for many years. Yet, with rapidly changing technology, the technicians who maintain your equipment will become scarcer as they move onto newer systems. Additionally, as your system ages, you must convert the format of more data from external sources. In this manner, the efficiency of the computer degrades. Thus, for computer systems, the ability to use it productively provide maintenance often limit the technological life.

Usually, economic life is the shortest of the technological, mission, or physical lives. Also, you should not project economic lives in excess of 30 years due to planning horizon limitations. Due to discounting, *cost streams beyond 30 years have little effect on decisions.*

CASH FLOW DIAGRAMS

You can depict life cycle costs with cash flow diagrams. A cash flow diagram is a pictorial technique for representing the magnitudes and timing of costs associated with an investment alternative. NOTE: While this manual represents the cash flows as if they occurred at the end of each year, it assumes that they occurred throughout the year.

Customarily, you draw cash flow diagrams for each alternative in the economic analysis. Draw a horizontal line to illustrate the entire project period. Divide the line into equal time periods and number each period chronologically. *Use the up arrow ↑ to illustrate cash inflows (receipts) and down arrow ↓ to represent cash outflows (costs).*

Example 7-1

Suppose a project has an economic life of six years. You spend $10,000 for equipment and $2,000 per year for maintenance. At the end of year six, the equipment has scrap value of $1,000. What does your cash flow diagram show?

Solution

Your initial investment of $10,000 occurs at "time zero" (right now). Costs of $2,000 occur each year. At the end of the sixth year, receipts of $1,000 represent the terminal sale value. Figure 7-1 shows your cash flow diagram.

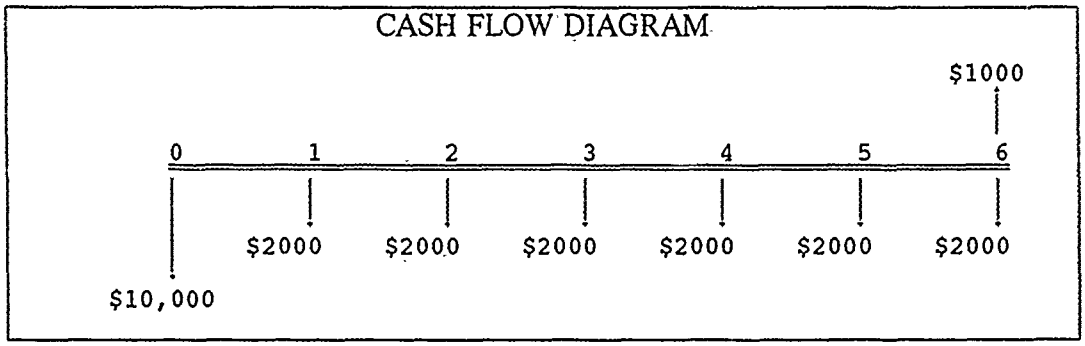


Figure 7-1

LEAD TIME AND PROJECT LIFE

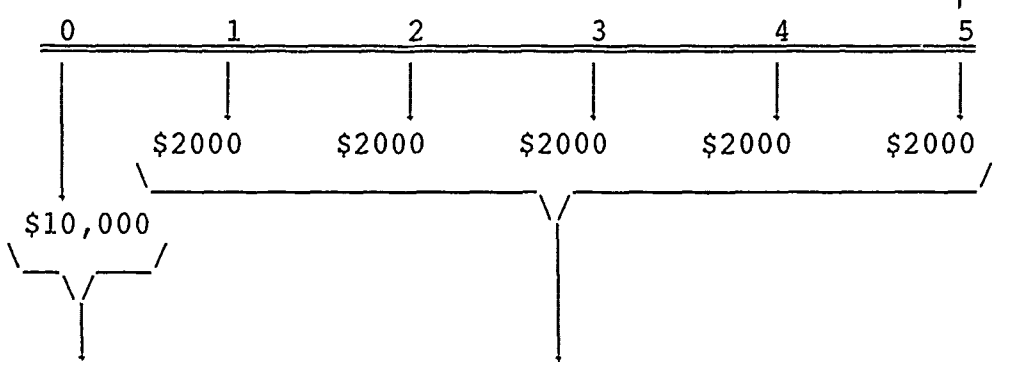
Investments sometimes occur several years prior to when the project starts providing benefits. The time between initial funding of the project and the commencement of the economic life is "lead time." Together, the lead time and the economic life become the project life. When you consider lead time as part of project life, you must alter the cash flow diagram.

CASH FLOW DIAGRAM
YEAR 0, YEAR 1 EXPLANATION

Year 0 represents the start of the project. For example, in years, how old is brand new equipment when you first buy it?

Year 1 represents the first "birthday" of the project. It marks the passing, not the beginning, of the first year.

The $1000 represents the money you receive when you sell your equipment. ---> $1000



The $10,000 represents the money you must pay up-front to start a project. For example, the purchase costs of your equipment.

Each $2,000 represents money you pay during the year for a particular project. For example, this is your annual payment for maintenance.

Figure 7-2

Example 7-2

Suppose a project requires two years of site preparation at $10,000 per year before you can begin a three-year production run costing $2000 per year. How do you show the two years on a cash flow diagram?

Solution

The two years are lead time. Figure 7-3 demonstrates the relationships among project life, economic life and lead time. The dashed line (= = =) represents lead time.

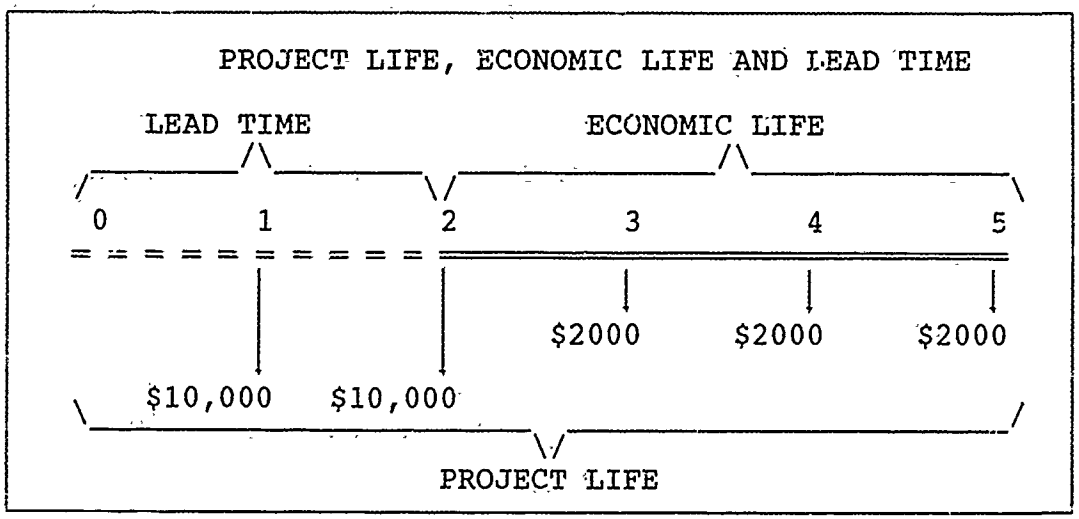


Figure 7-3

Whether you should include money spent during the lead time depends on the control you have over the money. If you have no control over whether you spend the money, do not include it in your analysis. Consider it a sunk cost. On the other hand, if your selection of an alternative changes the amount of money you spend, you must include it in your analysis.

PERIOD OF COMPARISON

Once you find out the economic and project lives of each alternative, you must decide over which period to compare the alternatives. Normally, set the period for the comparison so all alternatives start yielding benefits during the same year.

Because economic lives and lead times can vary among alternatives, DOD has established the following guidelines for determining a period of comparison:

1. Same Economic Lives and Lead times. If the economic lives and lead times for all alternatives are the same, compute alternatives over the same project life.

Example 7-3

Two alternatives require a two-year lead time before beginning a four year production run. What would the cash flow diagrams look like and how many years belong to the period of comparison?

Solution

You add two years of lead time with four years of the production run to have six years of project life. You evaluate the project over six years. Figure 7-5 shows the cash flow diagram:

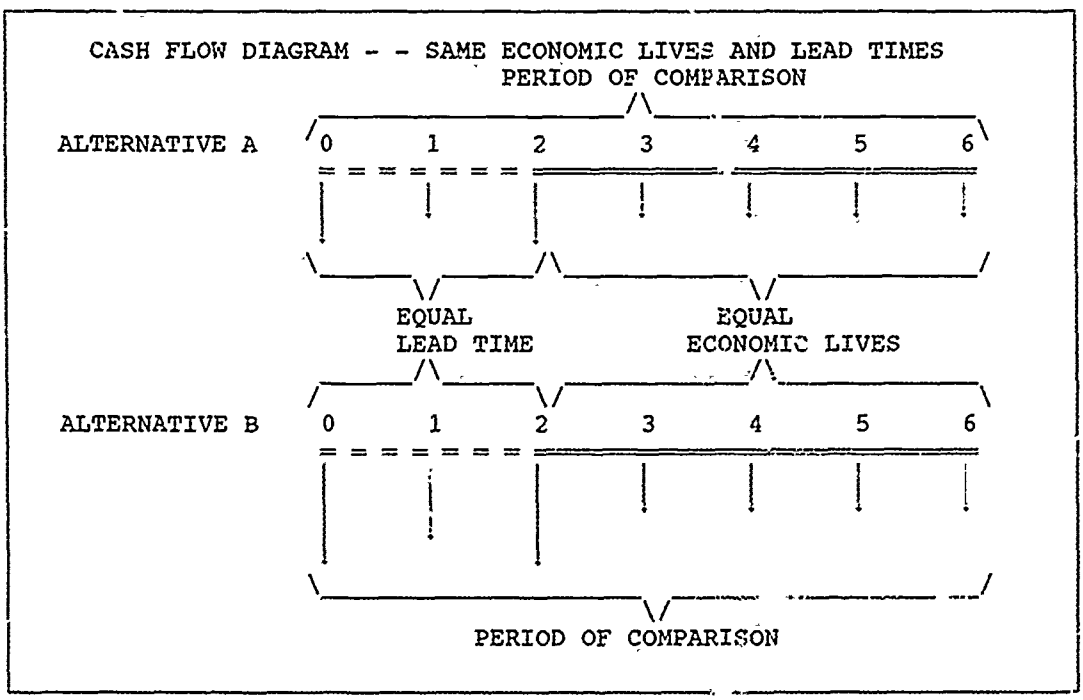


Figure 7-5

2. Same Economic Lives/Different Lead Times. If alternatives have the same economic lives, but different lead times, consider the first year with cash outflows as the base year or "project year one" for *all* alternatives.

Example 7-4

You have two ways to automate a manufacturing system. Both methods have the same economic lives but Alternative A needs three years for system development while Alternative B needs two years. How do you show this on cash flow diagrams?

Solution

Set the base year for the alternatives at the starting year for Alternative A. You assign Alternative B no costs for that year. This method imposes an appropriate opportunity cost for the capital to finance the earlier starting alternative.

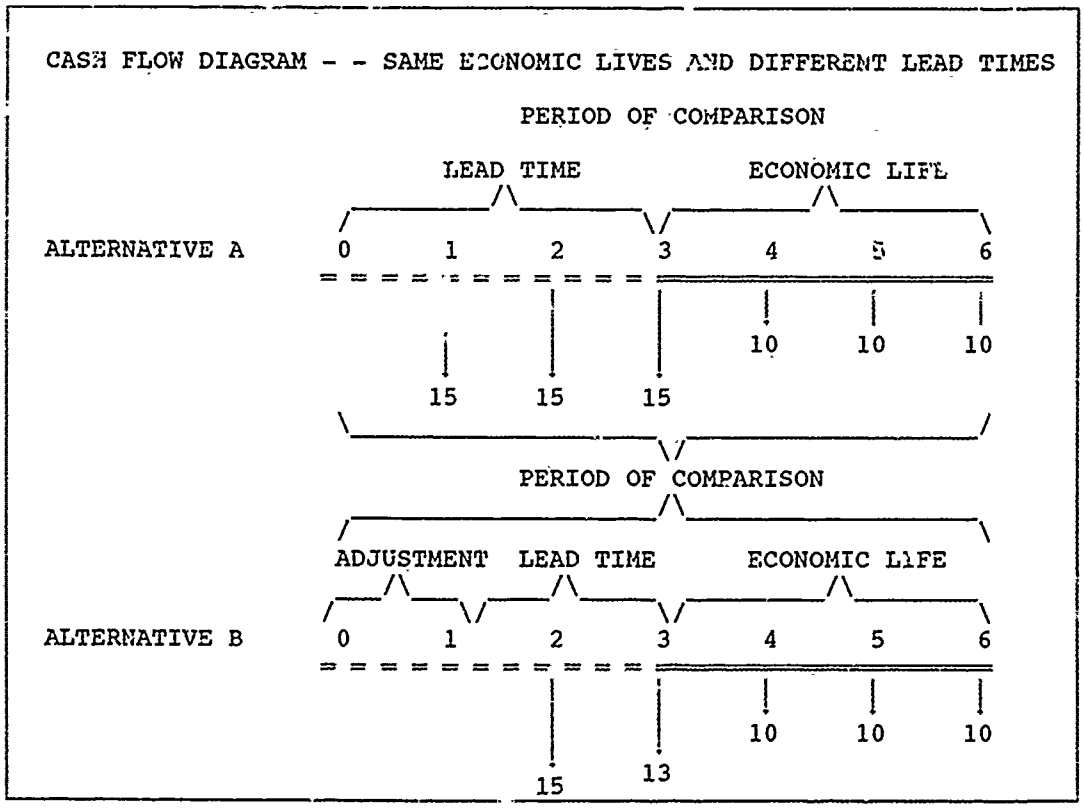


Figure 7-6

3. Different Economic Lives. When the economic lives of the alternatives are different, you can handle the problem several ways. The first is to let the asset with the longest economic life prevail while replacing other assets as necessary.

Example 7-5

Assume Machine A or Machine B, whose economic lives are six years and three years, meet your requirements. If let the asset with the longest economic life prevail while replacing other assets as required, what are your cash flow diagrams?

Solution

Employing the first method, you apply the costs over six years. At the end of three years, you have to replace Machine B with a similar machine. Figure 7-7 shows this alternative.

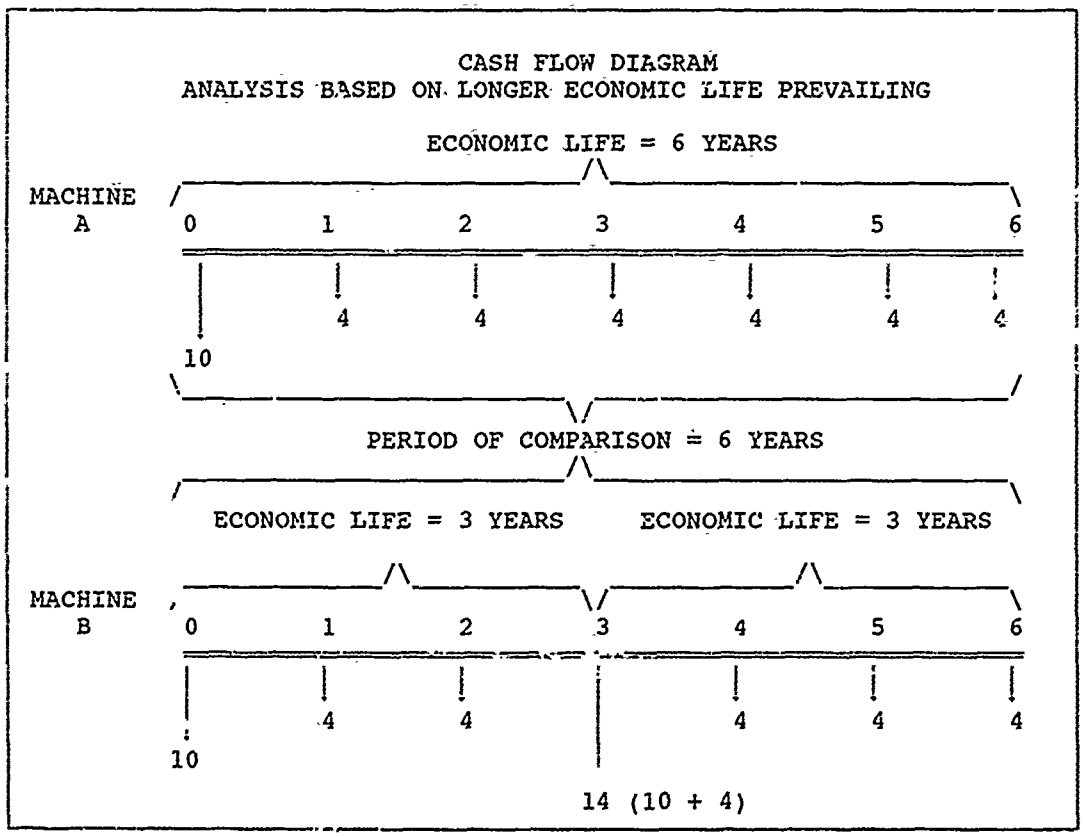


Figure 7-7

The second way is to use the shortest economic life and impute residual value to the asset with the longer life.

Example 7-6

In a case similar to example 7-5, assume you use the shorter economic life and impute residual value to the longer life asset. What are your cash flow diagrams?

Solution

Employing the second method, you apply the cost over three years and show the residual value for Machine A at the end of the third year. Figure 7-8 shows this:

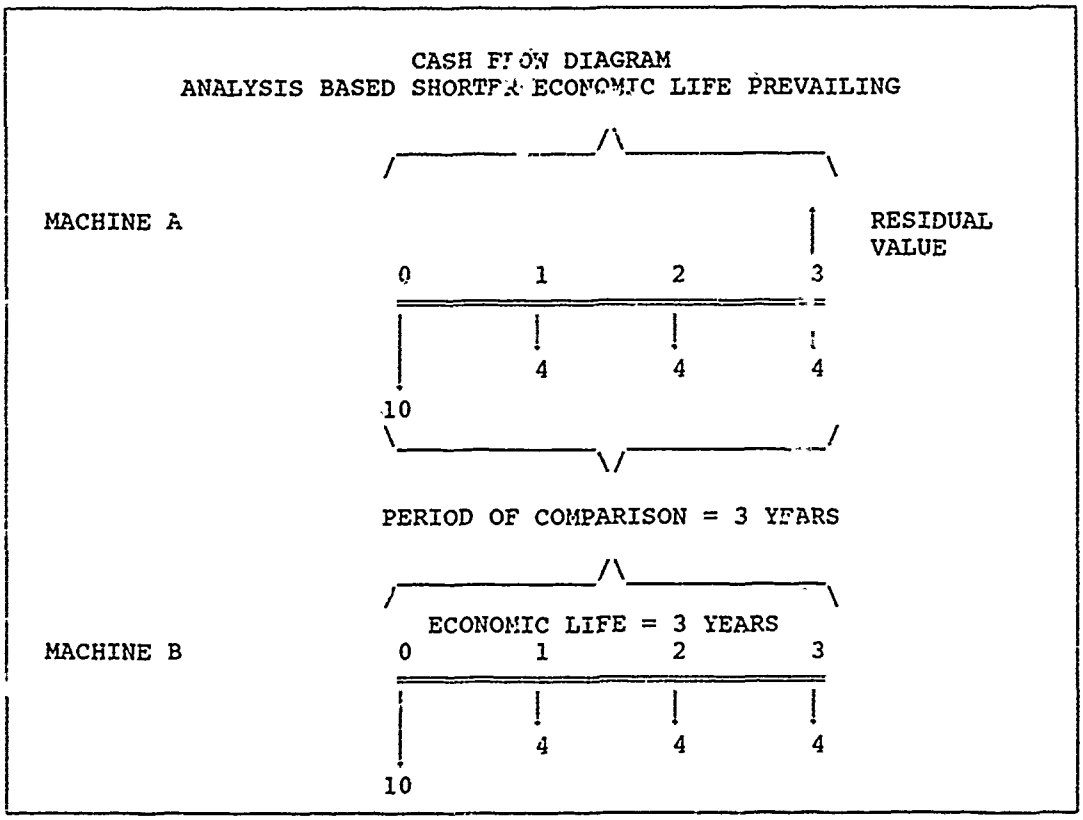


Figure 7-8

A third way of comparing alternatives with unequal economic lives is to use the Uniform Annual Cost technique. This cost-oriented approach puts life cycle cost and receipts for each alternative in terms of an average annual expenditure. Chapter 11 details this method.

CHAPTER 8

THE IDEA OF PRESENT VALUE

INTRODUCTION

As with other goods and services, money is a marketable commodity. You can buy and sell money in the marketplace. Generally, "goods or labor" is the purchase price of money.

"Interest" is the rental charge for money. You can explain the existence of interest by examining both the supply and the demand for money. By loaning money to another, you remove it from your available funds. In doing so, you deprive yourself of immediate satisfaction, that is, you cannot use this money to buy consumer goods now. For example, you make a sizable loan to a friend. While he has the money, you must delay your purchase of a new television, car, bass boat, or vacation.

Interest, the rent your friend pays to borrow your money, is your motivation to make the loan. The greater the fee or the higher the interest rate, the greater the motive to delay consumption to earn a return on invested money.

On the borrowing side, it is sometimes profitable for businesses to borrow money and pay the interest. This is because capital goods such as engineering equipment, machines, and structures return more income than they cost. It is rational for the government to pay interest on money invested in equipment that saves annual operating costs or improves service.

SIMPLE INTEREST

To understand the meaning of present value, you must understand how interest functions over time. Customarily, you express the interest rate as a percent or decimal. This represents the fractional amount of a loan the borrower must pay the lender within a specified interval of time. To figure out the amount of interest (I), you multiply the principal (P) by the rate of interest (i). You express this simple interest formula:

$$I = P * i$$

Additionally, if you borrow an amount of money (P) today at an annual interest rate i, at the end of the year you must return to the lender not only the original amount P but also the interest (I). Thus, the total future amount due (F_1) is:

$$\begin{aligned} F_1 &= P + I \\ &= P + (P * i) \\ &= P(1 + i) \end{aligned}$$

Example 8-1

Suppose you borrow $1,000 at an interest rate of 6%. What is the amount due to the lender one year from now?

Solution

$P = \$1{,}000 \qquad i = 6\%$

$F_1 = P(1 + i)$

$F_1 = \$1{,}000 * (1 + .06)$

$F_1 = \$1{,}000(1.06) = \underline{\$1{,}060}$

COMPOUND INTEREST -- THE FIRST YEAR

You calculate interest and principal for most accounts on a compound basis. Compound interest results from adding interest to principal in each period before calculating the interest on the new principal for the next period.

For example, you borrow $1000 at six percent interest, compounded annually. If you pay no principal the first year, at the end of the year you owe $1060. That is $1000 of the principal plus $60 of interest. At this point, your interest formula is the same as the simple interest formula: $I = P * i$. The amount due is: $F_1 = P(1 + i)$.

COMPOUND INTEREST -- THE SECOND YEAR

Suppose that from the example above, you borrow money but make no payments for the first two years. Again, at the end of the first year, you owe $1060. Yet, at the end of the second year you owe $1123.60, not $1120. The $3.60 difference is the effect of compounding. That is the original $1000 plus $60 of interest, plus $63.60 interest on $1060 in the next year.

The amount you must pay at the end of year two (F_2) becomes:

$$F_2 = P(1 + i) + i(P(1 + i))$$

$$= P(1 + i) * (1 + i)$$

$$= P(1 + i)^2$$

Example 8-2

Suppose you borrow $1,000 at a 6% interest rate, compounded annually for two years. What amount must you pay when the loan becomes due?

Solution

$F_2 = P(1 + i)^2$ P = $1,000 i = 6%

$= \$1{,}000(1.06)^2$

$= \$1{,}000(1.1236)$

$= \underline{\$1{,}123.60}$

COMPOUND INTEREST -- n YEARS

The difference between the expression for one year and two years is the addition of an exponent. Successive repetition of the above reasoning shows that if you borrow an amount P today at an annual interest i, the total amount owed to the lender, F_n, at the end of n years is:

$$F_n = P(1 + i)^n$$

Example 8-3

Suppose you borrow $1,000. The interest rate is 6% compounded annually. What will you owe four years from now if you make no payment until the end of year four?

Solution

$F_n = P(1 + i)^n$ P = $1,000 i = 6% n = 4

$F_4 = \$1000 * (1 + .06)^4$

$= \$1{,}000(1.2625)$

$= \underline{\$1{,}262}$

THE IDEA OF PRESENT VALUE

Time effects the value of money. If this is not readily apparent to you, imagine that you just won a lottery and the prize is millions of dollars. The lottery official calls to tell you the good news and asks one question. "Do you want to receive the millions of dollars this Monday, or do you want to receive it ten years from now?"

Most people want the money today. If you have the money today, you can buy food, shelter, and clothing. If you have the money today, you can invest it and expect to earn more money. If you have the money today, you have it. Can you be sure that you or the lottery official will be here in ten years?

Banks pay interest on deposits. People, businesses, and government pay interest on loans. This should tell you that money is worth more today than the same amount a year from now. This has nothing to do with inflation. Banks pay interest even during periods of falling prices. Utility, opportunity cost, and uncertainty ensure that you value money in your hand more than money you might receive later.

Thus, if you have a choice of receiving money now or ten years from now, there is little question of your preference. By accepting the money now, you could, through careful investment, have much more money in ten years.

The reverse of this principle applies to outflows of cash. Obviously, you probably prefer to pay $1,000 ten years from now than pay $1,000 today. Because of this time value of money, you must adopt some procedures to evaluate *future* cash flows in terms of *today's* money. You call this the present value of the money you expect to receive or spend in the future.

Economists and accountants recommend a common time basis adjustment known as discounting. Discounting is the reverse of compounding. Compounding moves a present value forward into the future. Discounting moves a future value back into the present.

The previous paragraphs on interest showed that the relationship of a single current amount of money and its future equivalent is:

$$F_n = P(1 + i)^n.$$

Algebraic manipulation converts this formula into its inverse. Thus, the present value (PV) discounting formula is:

$$PV = F_n * (1/((1. + i)^n)).$$

Example 8-4

You want to make a trust account for your new child so that she has $5,000 on her 21st birthday. At 4% interest, how much is this one-time deposit?

Solution

$$PV = F_n(1/(1 + i)^n) \quad F_n = \$5{,}000 \qquad i = 4\% \qquad n = 21$$

$$= \$5{,}000(1/(1.04)^{21})$$

$$= \$5{,}000(.438834)$$

$$= \underline{\$2{,}194}$$

At 4% interest, you can make the $5,000 gift twenty-one years from now by setting aside $2,194 today. $5,000 twenty-one years from now is worth $2,194 today.

VARYING THE DISCOUNT RATE

The discount rate and the timing of the cash flows can alter an economic analysis. Lower discount rates favor projects that create a late return on their investment. Higher discount rates favor projects that create an early return on their investment. Tables 8-1, 8-2, and 8-3 show the results of high and low discount rates on cash flows. As a common basis for the comparison, Figure 8-1 shows two cash flows, discounted at ten percent. Note: Both cash flows have accumulated present values of $500.

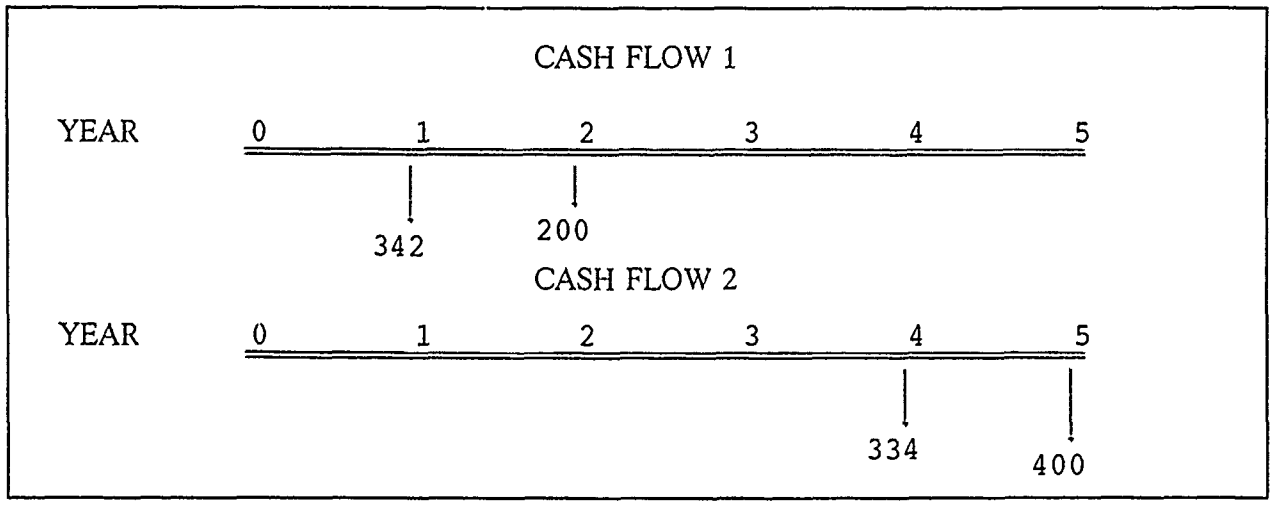


Figure 8-1

TABLE 8-1

CASH FLOW DIAGRAM SHOWING FRONT AND REAR END LOADING
10 PERCENT DISCOUNT RATE

CASH FLOW 1

YEAR	1	2	3	4	5
DISCOUNT FACTOR	0.955	0.868	0.789	0.717	0.652
x CASH FLOW	x 324	x 200	x 0	x 0	x 0
PRESENT VALUE	326	174	0	0	0
CUMULATIVE PV	326	500	500	500	500

CASH FLOW 2

YEAR	1	2	3	4	5
DISCOUNT FACTOR	0.955	0.868	0.789	0.717	0.652
x CASH FLOW	x 0	x 0	x 0	x 334	x 400
PRESENT VALUE	0	0	0	240	261
CUMULATIVE PV	0	0	0	240	500

Note that *CASH FLOW 2* has a significantly greater *absolute* cash flow to "pay" for the time value of money. Yet, using the ten percent discount rate, you conclude that the flows, economically speaking, are equals.

Tables 8-2 and 8-3 evaluate these cash flows, changing only the discount rate.

TABLE 8-2

CASH FLOW DIAGRAM SHOWING FRONT AND REAR END LOADING
ONE PERCENT DISCOUNT RATE

CASH FLOW 1

YEAR	1	2	3	4	5
DISCOUNT FACTOR	0.995	0.985	0.975	0.966	0.956
x CASH FLOW	x 324	x 200	x 0	x 0	x 0
PRESENT VALUE	340	197	0	0	0
CUMULATIVE PV	340	537	537	537	537

CASH FLOW 2

YEAR	1	2	3	4	5
DISCOUNT FACTOR	0.995	0.985	0.975	0.966	0.956
x CASH FLOW	x 0	x 0	x 0	x 334	x 400
PRESENT VALUE	0	0	0	323	382
CUMULATIVE PV	0	0	0	323	705

A one-percent discount factor favors investments having heavy, later year cash flows. In this diagram, both cash flows have a cumulative present value of $500 if you evaluate them at ten percent. Yet, when you evaluate them using a one percent discount rate, you create a difference, on paper, of $155.

A low discount rate gives little attention to the time value of money. Benefits the project gets in the late years can easily offset the investment costs you pay during the early years of a project. Thus, a low discount rate makes more projects appear feasible, enticing you to undertake more projects with low returns. Applied over the breadth of an organization, you reduce the efficiency of the organization. Applied over the entire nation, choosing poorer investments could lower the rate of national economic growth.

TABLE 8-3

CASH FLOW DIAGRAM SHOWING FRONT AND REAR END LOADING
19 PERCENT DISCOUNT RATE

CASH FLOW 1

YEAR	1	2	3	4	5
DISCOUNT FACTOR	0.920	0.773	0.650	0.546	0.459
x CASH FLOW	x 342	x 200	x 0	x 0	x 0
PRESENT VALUE	315	155	0	0	0
CUMULATIVE PV	315	469	469	469	469

CASH FLOW 2

YEAR	1	2	3	4	5
DISCOUNT FACTOR	0.920	0.773	0.650	0.546	0.459
x CASH FLOW	x 0	x 0	x 0	x 334	x 400
PRESENT VALUE	0	0	0	182	184
CUMULATIVE PV	0	0	0	182	366

A 19-percent discount factor favors investments having heavy, early year cash flows. In this diagram, both cash flows have a cumulative present value of $500 if you evaluate them at ten percent. Yet, when you evaluate them using a 19 percent discount rate, you create a difference, on paper, of $104.

A high discount rate, 19 percent compared to 1 percent, places a greater emphasis on current costs. Thus, the project's savings in the out years have less impact, offsetting investment costs. This lowers the incentive for investments.

CHAPTER 9

GOVERNMENT DISCOUNT RATES

INTRODUCTION

The government recognizes the effects of money on time. In the DOD, when evaluating investment projects, you must discount the costs or cash benefits when they go over three years from the project inception date. The prescribed DOD discount rate is ten percent.

The standard DOD discount rate provides several benefits. First, you do not have to research for an appropriate rate. Second, using the DOD rate provides a common basis for economic analysis. Finally, the DOD rate stops you from altering the rate to make one alternative look better than another.

Use the ten percent discount factor to evaluate government projects. Both DOD Instruction 7041.3 and Office of Management and Budget (OMB) Circular A-94, "Discount Rates to be used in evaluating time-distributed costs and benefits," endorse this rate and consider it to be the most representative rate, now. This rate is an estimate of the average rate of return on private investment before corporate taxes and after adjusting for inflation. Thus, the ten percent rate is the weighted average opportunity cost of taking money from the private sector.

PRESENT VALUE TABLES

Chapter 8 developed the discount factor $1/(1+i)^n$. You can easily apply this formula to simple examples where cash flows occur in the early years of the project. Yet, when you evaluate more complex projects involving cash flows throughout the economic life, the computational task of applying the formula becomes tedious. Pre-compiled tables, such as Table 9-4, a convenient list of 10% discount factors, make computation of present values easier.

The factors in Table 9-1 are "end-of-year" factors. They assume that the cash flows occur precisely at the ends of years. Generally, costs occur throughout the year. When costs equally occur throughout the year, the midpoint of the year represents the average time of spending. The DOD currently employs factors derived from the standard present value formula to represent an average for the year.

TABLE 9-1

PRESENT VALUE - 10% DISCOUNT FACTOR

YEAR	PRESENT VALUE FORMULA	PRESENT VALUE FACTOR
0	$\frac{1}{(1 + .1)^0}$	1.000
1	$\frac{1}{(1 + .1)^1}$	0.909
2	$\frac{1}{(1 + .1)^2}$	0.826
3	$\frac{1}{(1 + .1)^3}$	0.751
4	$\frac{1}{(1 + .1)^4}$	0.683
5	$\frac{1}{(1 + .1)^5}$	0.621

Table 9-2 illustrates the conversion from-end-of-year to average factors. Table A of Appendix C provides a complete list of present value factors for years 1-30.

TABLE 9-2

END OF YEAR VERSUS AVERAGE DISCOUNT FACTORS (10%)

YEAR	END OF YEAR FACTOR	AVERAGE FACTOR FORMULA	AVERAGE FACTOR
0	1.000	$((1/(1+.1)^0)+(1/(1+.1)^0))/2$	1.000
1	0.909	$((1/(1+.1)^0)+(1/(1+.1)^1))/2$	0.955
2	0.826	$((1/(1+.1)^1)+(1/(1+.1)^2))/2$	0.868
3	0.751	$((1/(1+.1)^2)+(1/(1+.1)^3))/2$	0.789
4	0.683	$((1/(1+.1)^3)+(1/(1+.1)^4))/2$	0.717
5	0.621	$((1/(1+.1)^4)+(1/(1+.1)^5))/2$	0.652

The rationale for using average factors instead of end-of-year factors is:

1. After the initial investment cost, most of the annual costs and benefits associated with a project do not occur at a single time. Instead, they occur throughout the year. This is typically true of operating costs and salaries. If these costs occur uniformly throughout the year, a mid-year, annual lump sum payment will approximate these costs.

2. You may not know with certainty the exact time of occurrence of costs and benefits in the out years of an economic life. In the absence of more specific information, you have no reason to assume that these costs and benefits will occur only on the anniversaries of acquisition; they might occur at any point in the year. If costs occur randomly throughout the year with a normal distribution, you could apply average factors to them. Errors on the low side should occur about as often as errors on the high side. Eventually, the errors offset themselves.

Example 9-1

As one alternative in a certain project, your department is considering leasing additional computer space for a four year period. Annual rental would amount to $10,000. What will be the total discounted cost if you choose this alternative?

Solution

Use Table A discount factors to figure out the present value (PV):

PV = $10,000(.954)+$10,000(.867)+$10,000(.788)+$10,000(.717)
= $9,540 + $8,670 + $7,880 + $7,170 = $33,260

To simplify the calculations, factor the recurring $10,000 from each term. This entails finding the sum of the first four Table A factors, then performing a single multiplication. Thus:

PV = $10,000(0.954 + 0.867 + 0.788 + 0.717).

You may simplify this further using Table B of Appendix C, a list of cumulative sums of Table A factors. Using Table B, the corresponding cumulative discount factor for the above problem is 3.326. Thus, the present value becomes:

PV = $10,000(3.326) = $33,260

Still, a final simplification is the use of a computer. Table 9-3 is a computer spreadsheet presentation of the cash flows and their present value.

TABLE 9-3

SPREADSHEET PRESENTATION
EXAMPLE 9-1

YEAR	0	1	2	3	4
DISCOUNT FACTOR	1.000	0.955	0.868	0.789	0.717
x COSTS	x 0	x 10,000	x 10,000	x 10,000	x 10,000
PRESENT VALUE	0	9,545	8,677	7,888	7,171
CUMULATIVE PV	0	9,545	18,223	26,111	33,283

While this is the same result obtained earlier using Table A factors, discrepancies occasionally occur between answers you calculate using the Table A method and a computer. Assuming your arithmetic is correct, you may attribute these to rounding. A computer can use a mathematical formula to find its factors, instead of the addition of Table A factors.

Example 9-2

You are planning to automate a local management information system. One alternative you consider has an eight year life and projected costs as follows:

Initial Costs	$35,000
Operating Costs	
Year 1	2,000
Year 2	2,500
Years 3-8	3,000

What is the discounted cost if you choose this alternative?

Solution

This problem involves the use of both Table A and Table B. To discount the single amount factors in years 1 and 2, use Table A factors. Years 3-8, however, involve a uniform series of costs. For these years, consider the difference between the 2nd year factor and the 8th year factor and apply Table B factors. Thus, for this example the cumulative discount factor for years 3-8 is 3.776(5.597 - 1.821).

Therefore, the total present value is:

PV = $35,000 + $2000 (.954) + $2,500 (.867) + $3,000(3.776)
= $35,000 + $1,908 + $2,168 + $11,328
= $50,404

Table 9-4 is a computer spreadsheet representation of this problem. Due to rounding, the totals vary slightly.

TABLE 9-4

SPREADSHEET PRESENTATION

EXAMPLE 9-2

YEAR	0	1	2	3	4	5	6	7	8
DISCOUNT FACTOR	1.000	0.955	0.868	0.789	0.717	0.652	0.593	0.539	0.490
COST	35000	2000	2500	3000	3000	3000	3000	3000	3000
PRESENT VALUE	35000	1909	2169	2366	2151	1955	1778	1616	1469
CUMULATIVE PV	35000	36909	39078	41445	43596	45552	47330	48947	50416

Two general rules for cumulative discount factors are:

Rule 1 - To find the present value of a series of uniform recurring cash flows beginning in year 1 and continuing through year n, multiply the amount of the annual payment by the nth year factor from Table B, Appendix C.

Rule 2 - To find the present value of a series of uniform recurring cash flows beginning in year m and continuing through year n, multiply the amount of the annual payment by the difference between the factors for year n and year m-1 in Table B, Appendix C.

Example 9-3

Suppose your company is evaluating its ability to provide Automated Data Processing (ADP) support to the Maritime Pre-positioned Shipping (MPS) program. From the data you have collected, this effort should net $100,000 annual revenue for your company. Currently, a competitor provides ADP support, but their contract expires in 2 years. Then, the government will issue a new 5-year contract. You will need that much lead time to prepare a system for MPS support and you may have to buy new equipment today to do this. If you will get the contract, what is its present value?

Solution

First, you need to identify in which future years the cash flows occur. Because of the 2-year lead time, the cash flows occur during years 3, 4, 5, 6, and 7. Note, m = 3, n = 7. Next, go to Appendix C, Table B and find the cumulative discount factors. In this example, these are the cumulative discount factors for years 2 (m-1) and 7 (n). The cumulative discount factors are 1.821 and 5.108. Finally, subtract the first year factor from the last year factor and multiply the difference by the cash flow:

$$PV = (5.108 - 1.821) \times \$100,000$$

$$= 3.287 \times \$100,000 = \underline{\$328,700}$$

COMMON MISCONCEPTIONS ABOUT THE TEN PERCENT RATE

Several misconceptions have arisen regarding the ten percent discount factor. Some more common ones are:

1. Some people see the ten percent factor as compensation for the rate of inflation. Do not confuse the process of discounting with inflation. While the ideas recognize the future dollars are not worth as much as today's dollar, the similarity soon ends. Inflation treats the future dollar for anticipated erosion of the purchasing power of today's dollar (a cup of coffee today costs 75 cents, but you expect the same coffee to cost one dollar in the future). Discounting adjusts a given future dollar level to reveal how many dollars today, drawing interest at a given compound rate, would equate the same number of dollars at the given future date. This is the present value of future dollars. The ten percent discount factor more closely associates with the prime rate and long term bond rate.

2. Some argue that you should not consider the time value of money when evaluating Government investment proposals because the Government lacks the option of "banking" money to earn a return. Congress sets the budget. Money the government does not spend on one project it spends on another. You can't invest it to earn interest as in the private sector. Recognize that the "return"

implied by the ten percent discount rate does not refer to the result of the Government holding money. The return applies to the opportunity cost imputed through the transfer of resources from the private to the public sector.

The Federal Government's investment objective should be to maximize the economic well-being of the nation as a whole. This means that the government must maximize the rate of return from invested resources, whether the investor is private or public. Therefore, in analyzing an investment, the Federal Government must consider the possible return if they left the funds in the private sector. That is the cost of money or the possible return in the private capital market. This is the conceptual basis for considering time value of money or capital costs of government expenditures.

3. One school of thought maintains that you should set the discount rate equal to the rate paid by the Treasury in borrowing money. This idea uses the premise that if you undertake particular projects using borrowed funds, you must base the minimum rate of return on the rate of those borrowed funds. Still, the government does not finance investment solely with borrowed funds. The government raises most revenue through taxation and uses this involuntary transfer of wealth to finance most government investments. This money could fund private investment. Thus, the private sector rate of return is appropriate.

PART IV - COMPARING ALTERNATIVES

CHAPTER 10

PRESENT VALUE ANALYSIS

INTRODUCTION

You may use several techniques to compare alternatives. Each incorporates the discounting principles that Chapter 9 describes. Present value analysis is an appropriate technique to use whenever the benefits and project lives are the same for all alternatives or when you cannot quantify the benefits. Doing a present value analysis is an easy way to compare alternatives. To perform present value analysis, you put all costs and receipts for each alternative in terms of their worth, as of the date you compare them. The alternative having the lowest present value cost is the least cost alternative. You should recommend it.

USING PRESENT VALUE ANALYSIS

To use present value analysis as the sole basis for decision making, the following conditions must apply:

1. Benefits for all alternatives must be equal. If benefits are not equal, the least costly alternative may not be the best alternative. The best alternative may be the one that costs the most, yet produces significantly greater benefits. Thus, when benefits are unequal, you should not base your decision solely on the present value analysis. In such a case, you use the Benefit Cost Ratio as Chapter 15 explains.

2. Service lives of the alternatives must be finite. That is, the estimated life of the alternative has a start and stop date. For example, you estimate that Printer A has a life of 6 years. You estimate that Printer B has a life of 12 years.

3. Service lives of alternatives must be equal, or else you must place them on equal terms. You can do this two ways. The first approach is the "common multiple approach." For example, since you would replace Printer A after six years, you can compare both Alternatives A and B on the 12 year service life base. Second, you could compare the alternatives using the shorter life and imputing the residual value of the asset with the longer life. Here, you would use a six year life. At the end of the sixth year you would include the residual value of Printer B as a lump sum in the analysis.

Example 10-1

Suppose two machine do the identical work. Machine A has an economic life of six years, costs $10,000 to buy and $4,000 per year to operate. Machine B has an economic life of 3 years, costs $8,000 to buy and $5,000 per year to operate. Neither machine has salvage value at the end of its economic life. Using present value analysis, which machine should you buy?

Solution

1. Using a six year period of comparison:

   a. Figure 10-1 shows the cash flow diagrams.

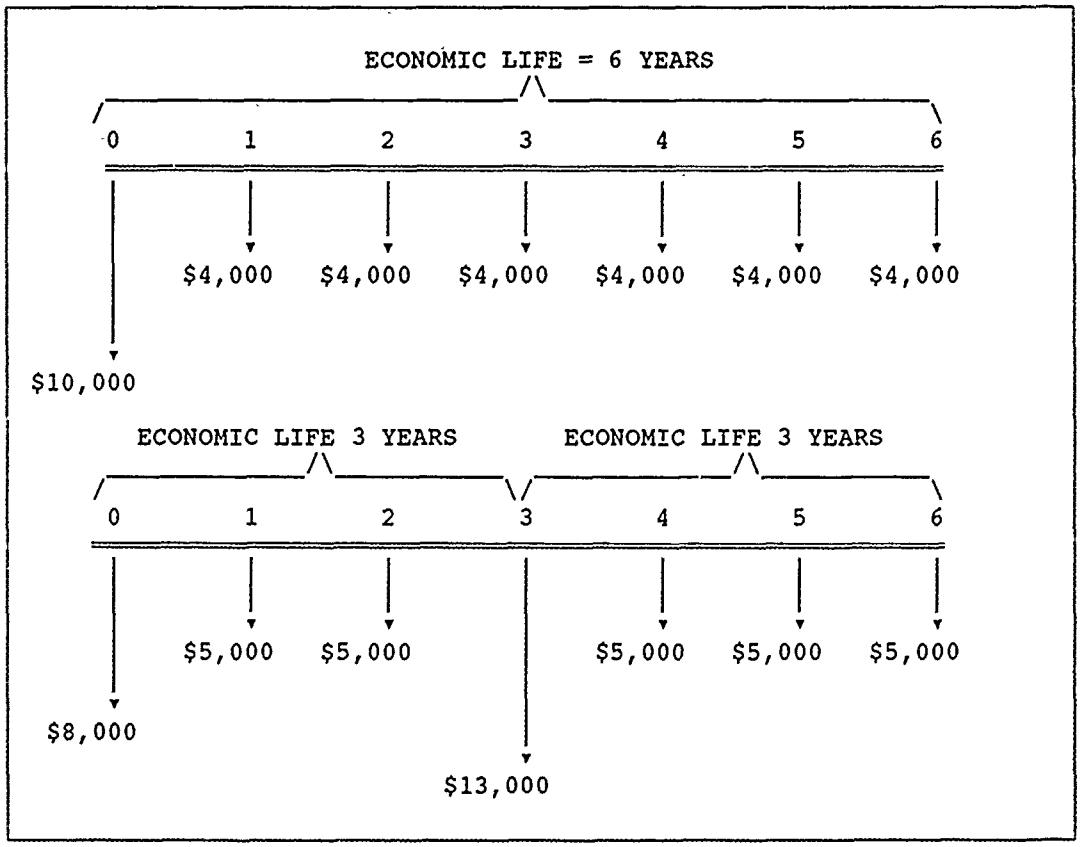


Figure 10-1

   b. Table 10-1 is a present value analysis spreadsheet for this solution.

TABLE 10-1

PRESENT VALUE ANALYSIS
EXAMPLE 10-1

MACHINE A
ECONOMIC LIFE SIX YEARS

YEAR	0	1	2	3	4	5	6
DISC FACTOR	1.000	0.955	0.868	0.789	0.717	0.652	0.593
x CASH FLOW	x $10,000	x $4,000	x $4,000	x $4,000	x $4,000	x $4,000	x $4,000
PV CASH FLOWS	$10,000	$3,818	$3,471	$3,156	$2,869	$2,608	$2,371
ACCUMULATED PV	$10,000	$13,818	$17,289	$20,445	$23,313	$25,921	$28,292
PV MACHINE A							$28,292

MACHINE B
ECONOMIC LIFE 3 YEARS

MACHINE B
ECONOMIC LIFE 3 YEARS

YEAR	0	1	2	3	4	5	6
DISC FACTOR	1.000	0.955	0.868	0.789	0.717	0.652	0.593
x CASH FLOWS	x $8,000	x $5,000	x $5,000	x $13,000	x $5,000	x $5,000	x $5,000
PV CASH FLOWS	$8,000	$4,773	$4,339	$10,225	$3,586	$3,260	$2,963
ACCUMULATED PV	$8,000	$12,773	$17,112	$27,367	$30,953	$34,213	$37,176
PV MACHINE B							$37,176

Solution (continued)

c. The present value costs are:

$PV_A = \$10{,}000 + \$4{,}000\ (4.573) = \underline{\$28{,}292}$

$PV_B = \$8{,}000 + \$5{,}000\ (4.573) + \$8{,}000\ (.789) = \underline{\$37{,}176}$

2. Using a three-year period of comparison:

a. Figure 10-2 depicts the cash flow diagrams.

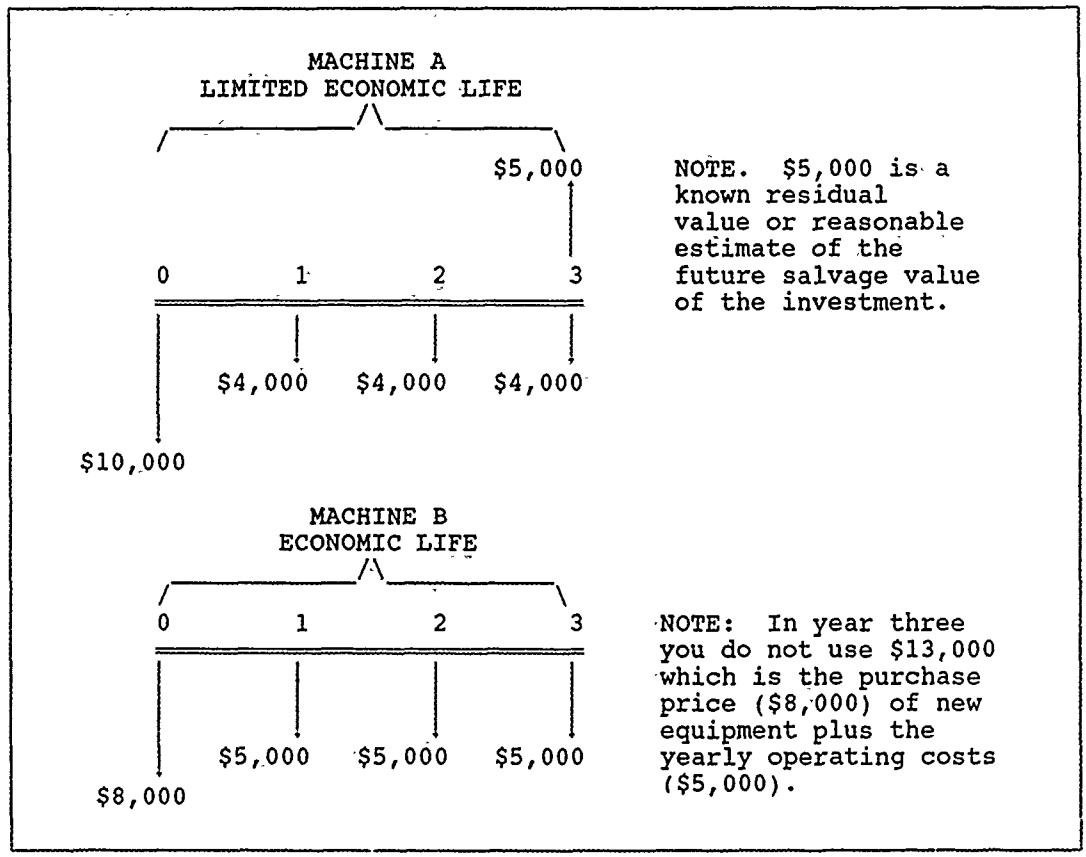


Figure 10-2

b. Table 10-2 is a spread sheet of the present value analysis using a three year period of comparison.

(Solution Continued) TABLE 10-2

PRESENT VALUE ANALYSIS
3 YEAR ECONOMIC LIFE LIMIT

MACHINE A
LIMITED 3 YEAR ECONOMIC LIFE

YEAR	0	1	2	3
CASH FLOW x DISC FACTOR	$10,000 x 1.000	$4,000 x 0.955	$4,000 x 0.868	($1,000) x 0.789
PRESENT VALUE CASH FLOWS	$10,000	$3,818	$3,471	($789)
ACCUMULATED PRESENT VALUE	$10,000	$13,818	$17,289	$16,500
TOTAL PV MACHINE A				$16,500

MACHINE B
3 YEAR ECONOMIC LIFE

YEAR	0	1	2	3
CASH FLOW x DISC FACTOR	$8,000 x 1.000	$5,000 x 0.955	$5,000 x 0.868	$5,000 x 0.789
PRESENT VALUE CASH FLOWS	$8,000	$4,773	$4,339	$3,944
ACCUMULATED PRESENT VALUE	$8,000	$12,773	$17,112	$21,056
TOTAL PV MACHINE B				$21,056

(Solution Continued)

c. The present values of Alternatives A and B for a three year period are:

$$PV_A = \$10{,}000 + \$4{,}000(2.609) - \$5{,}000(.789) = \underline{\$16{,}491}$$
$$PV_B = \$8{,}000 + \$5{,}000(2.609) = \underline{\$21{,}045}$$

PRESENTING A PRESENT VALUE ANALYSIS

The present value analysis has no set format. You may design a format to meet your needs for displaying the data. Still, you must organize the information to identify the discounted costs for each year of the project life.

Example 10-2

Your office may lease equipment for $11,000 per year to automate its manual accounting system. System development will cost $20,000 and take one year. Rental fees include maintenance costs. Automation will reduce labor and operating costs from a present $35,000 to $19,000. The project life of the system is 6 years. Compute the present value of the manual and automated systems.

Solution

1. The cash flow diagrams for the manual and automated system are:

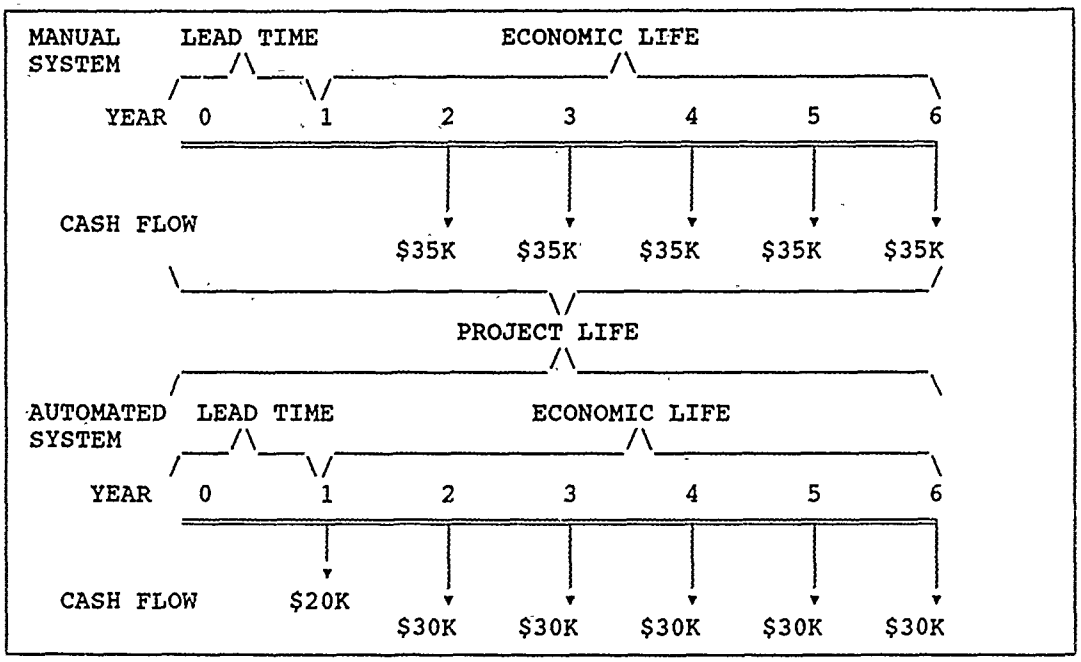


Figure 10-2

2. Table 10-3 presents the present value analysis and shows the difference between an alternative and current operation. A positive difference is increased costs above today's operation. A negative difference is savings from using the alternative. Here, the alternative increases life cycle costs by $999.

(Solution Continued) TABLE 10-3

PRESENT VALUE ANALYSIS

DIFFERENTIAL COSTS

PROJECT YEAR	1	2	3	4	5	6
PRESENT MANUAL SYSTEM One time costs Recurring costs		$35,000	$35,000	$35,000	$35,000	$35,000
PROPOSED ALTERNATIVE Nonrecurring Recurring Cost	$20,000	30,000	30,000	30,000	30,000	30,000
DIFFERENTIAL COST or (SAVINGS)	$20,000	($5,000)	($5,000)	($5,000)	($5,000)	($5,000)
DISCOUNT FACTOR	x.955	x.868	x.789	x.717	x.652	x.593
PRESENT VALUE COST or (SAVINGS)	$19,091	($4,339)	($3,944)	($3,586)	($3,260)	($2,963)
CUMULATIVE COST or (SAVINGS)	$19,091	$14,752	$10,808	$7,222	$3,962	$999
PRESENT VALUE						$999

Perform the economic analyses of alternative methods of acquisition with care and precision. Frequently, the same vendor will not be low on both lease and purchase plans. The following example describes four acquisition methods:

Example 10-3

Alternative 1 - Purchase	
1. Purchase price	$610,000
2. Annual maintenance of Government owned equipment	
Year 1	22,300
Years 2-6	29,700
3. Residual value	(122,000)
Alternative 2 - Lease to Own	
(title transfer at the end of 6 yrs)	
1. Annual lease	$144,000
2. Residual value	(122,000)
Alternative 3 - Long Term Lease	
1. Annual lease	$132,000
Alternative 4 - Lease with Option to Purchase	
(option exercised at the end of 18 months).	
1. Annual lease	$156,000
2. Purchase price	610,000
3. Purchase option credit of 80% of rental paid (156*1.5=225*.8)	(187,200)
4. Annual maintenance of Government owned equipment	29,700
5. Residual value	(122,000)

Solution

This example assumes that you do not have a current system or that the current system is not a viable alternative. This is different from example 10-2. Tables 10-4 through 10-7 show the present value analysis for Alternatives 1 through 4. Alternative 2 is the least costly alternative at $586,206.

(Solution Continued)

TABLE 10-4

PRESENT VALUE ANALYSIS
ALTERNATIVE: PURCHASE

PROJECT YEAR	0	1	2	3	4	5	6
COSTS nonrecurring + recurring	$610,000	 $22,300	 $29,700	 $29,700	 $29,700	 $29,700	 -122,000 $29,700
TOTAL COSTS DISCOUNT FACTOR	x 1.000	$22,300 x .955	$29,700 x .868	$29,700 x .789	$29,700 x .717	$29,700 x .652	-$92,300 x .593
DISCOUNTED COSTS	$610,000	$21,286	$25,780	$23,433	$21,295	$19,364	-$54,734
CUMULATED DISCOUNTED COSTS	$610,000	$631,286	$657,066	$680,499	$701,794	$721,058	$666,324
PRESENT VALUE							$666,324

(Solution Continued)

TABLE 10-5

PRESENT VALUE ANALYSIS
ALTERNATIVE: LEASE TO OWN

PROJECT YEAR	0	1	2	3	4	5	6
COSTS nonrecurring + recurring		$144,000	$144,000	$144,000	$144,000	$144,000	-122,000 $144,000
TOTAL COSTS DISCOUNT FACTOR	x 1.000	$144,000 x .955	$144,000 x .868	$144,000 x .789	$144,000 x .717	$144,000 x .652	$21,400 x .593
DISCOUNTED COSTS		$137,455	$124,959	$113,599	$103,272	$93,883	$13,039
CUMULATED DISCOUNTED COSTS		$137,455	$262,413	$376,012	$479,284	$573,167	$586,206
PRESENT VALUE							$586,206

(Solution Continued) TABLE 10-6

PRESENT VALUE ANALYSIS
ALTERNATIVE: LONG TERM LEASE

PROJECT YEAR	0	1	2	3	4	5	6
COSTS nonrecurring + recurring		$132,000	$132,000	$132,000	$132,000	$132,000	$132,000
TOTAL COSTS DISCOUNT FACTOR	x 1.000	$132,000 x .955	$132,000 x .868	$132,000 x .789	$132,000 x .717	$132,000 x .652	$132,000 x .593
DISCOUNTED COSTS		$126,000	$114,545	$104,132	$94,666	$86,060	$78,236
CUMULATED DISCOUNTED COSTS		$126,000	$240,545	$344,678	$439,343	$525,403	$603,639
PRESENT VALUE							$603,639

(Solution Continued)

TABLE 10-7

PRESENT VALUE ANALYSIS
ALTERNATIVE: LEASE WITH OPTION TO PURCHASE

PROJECT YEAR	0	1	2	3	4	5	6
COSTS nonrecurring + recurring		$156,000	$422,800 92,800	$29,700	$29,700	$29,700	-$122,000 $29,700
TOTAL COSTS DISCOUNT FACTOR	x 1.000	$156,000 x .955	$515,600 x .868	$29,700 x .789	$29,700 x .717	$29,700 x .652	$92,300 x .593
DISCOUNTED COSTS		$148,909	$447,421	$23,430	$21,300	$19,363	-$54,706
CUMULATED DISCOUNTED COSTS		$148,909	$596,331	$619,760	$641,060	$660,424	$605,718
PRESENT VALUE							$605,718

Example 10-4

A naval base on the east coast currently contracts all ADP work to a commercial timesharing company. The base commander believes that the current costs are too high. He tells you to perform an economic analysis to evaluate alternative means of acquiring ADP support. You must analyze and evaluate three alternatives: The first is a commercial time sharing system. The second is your current, in-house system. The final alternative is NARDAC support. You will purchase equipment and modify your facility during FY 1.

Alternative 1 - Commercial Timesharing

Remote Job Entry (RJE) Equipment Rental	$30,000	per year FY2 through FY6
Telecommunications	35,000	per year FY2 through FY6
Timesharing Services	285,000	per year FY2 through FY6

Alternative 2 - In-House

ADP Maintenance	$36,000	per year FY2 through FY6
Operating Personnel	50,000	per year FY2 through FY6
ADPE Purchase	570,000	
Site preparation	50,000	
System Conversion	173,000	
ADPE Residual Value	57,000	at end of FY6

Alternative 3 - NARDAC Support

System Conversion	$234,000	
RJE Equipment Rental	30,000	per year FY2 through FY6
Telecommunications	25,000	per year FY2 through FY6
NARDAC Operating Costs	125,000	per year FY2 through FY6

Solution

Tables 10-8 through 10-10 show the results of the analysis. The NARDAC alternative has the lowest present value cost. Therefore, it is the least costly alternative.

(Solution Continued)

TABLE 10-8

PRESENT VALUE ANALYSIS
ALTERNATIVE: COMMERCIAL TIME SHARING

COST ELEMENT	FY 2	FY 3	FY 4	FY 5	FY 6
Recurring Cost:					
RJE Equipment Rental	$30,000	$30,000	$30,000	$30,000	$30,000
Telecommunications	35,000	35,000	35,000	35,000	35,000
Timesharing Service	285,000	285,000	285,000	285,000	285,000
TOTAL UNDISCOUNTED COSTS	$350,000	$350,000	$350,000	$350,000	$350,000
x DISCOUNT FACTOR	x .868	x .789	x .717	x .652	x .593
TOTAL DISCOUNTED COST	$303,719	$276,108	$251,007	$228,189	$207,4446
CUMULATED DISCOUNTED COSTS	$303,719	$579,827	$830,834	$1,059,023	$1,266,467
PRESENT VALUE					$1,266,467

(Solution Continued) TABLE 10-9

PRESENT VALUE ANALYSIS
ALTERNATIVE: IN-HOUSE

COST ELEMENT	FY 1	FY 2	FY 3	FY 4	FY 5	FY 6
Recurring Cost:						
ADP Maintenance		$36,000	$36,000	$36,000	$36,000	$36,000
Operating Personnel		50,000	50,000	50,000	50,000	50,000
One-time Costs:						
ADPE Purchase	$570,000					
Site Preparation	50,000					
System Conversion	173,000					
ADPE Residual Value						(57,000)
TOTAL UNDISCOUNTED COSTS	$793,000	$86,000	$86,000	$86,000	$86,000	$29,000
x DISCOUNT FACTOR	x .955	x . 868	x .789	x .717	x .652	x .593
TOTAL DISCOUNTED COST	$756,955	$74,628	$67,844	$61,676	$56,069	$17,188
CUMULATED DISCOUNTED COSTS	$756,955	$831,583	$899,427	$961,103	$1,017,172	$1,034,360
PRESENT VALUE						$1,034,360

(Solution Continued)

TABLE 10-10

PRESENT VALUE ANALYSIS
ALTERNATIVE: NARDAC SUPPORT

COST ELEMENT	FY 1	FY 2	FY 3	FY 4	FY 5	FY 6
Recurring Cost:						
RJE Equipment rental		$30,000	$30,000	$30,000	$30,000	$30,000
Telecommini-cations		25,000	25,000	25,000	25,000	25,000
NARDAC Operating Cost		125,000	125,000	125,000	125,000	125,000
One-time Costs:						
System Conversion	$234,000					
TOTAL UNDISCOUNTED COSTS	$234,000	$180,000	$180,000	$180,000	$180,000	$180,000
x DISCOUNT FACTOR	x .955	x . 868	x .789	x .717	x .652	x .593
TOTAL DISCOUNTED COST	$223,364	$156,198	$141,998	$129,090	$117,354	$106,686
CUMULATED DISCOUNTED COSTS	$223,364	$379,562	$521,560	$650,650	$768,004	$874,690
PRESENT VALUE						$874,690

CHAPTER 11

UNIFORM ANNUAL COSTS

INTRODUCTION

So far, this book limited the comparisons of investment proposals to the use of the present value technique. This involves putting all costs and receipts for each alternative in terms of their worth as of the date you make a comparison. The present value technique best fits alternatives having equal economic lives. Yet, the economic lives frequently differ from alternative to alternative. The ***Uniform Annual Cost (UAC)*** method puts all the alternatives on a common basis of time to make a valid comparison.

UNIFORM ANNUAL COST

The UAC technique is a cost oriented approach you use to evaluate alternatives with unequal economic lives. The technique involves putting all life cycle costs and receipts for each alternative in terms of an average annual expenditure. The alternative with the lowest UAC is the most economical choice.

When using the UAC method to evaluate alternatives, apply the following assumptions:

1. The cash flow diagrams represent alternatives meeting the same requirements specification.

2. You see no end to the requirement and technological considerations play no significant role. Thus, the physical lives constrain the economic lives of Alternatives A and B.

3. The only costs associated with each alternative are the uniform recurring costs.

4. The two alternatives provide an equivalent level of benefits per year. Thus, even if you cannot quantify the benefits, an alternative with a longer economic life will produce more benefits over the course of its life.

5. The annual cost of one alternative exceeds that of the other alternative.

6. You may repeat each alternative indefinitely, with the same cash flow pattern.

To understand the rationale behind this technique, consider the cash flow diagrams in Figure 11-1.

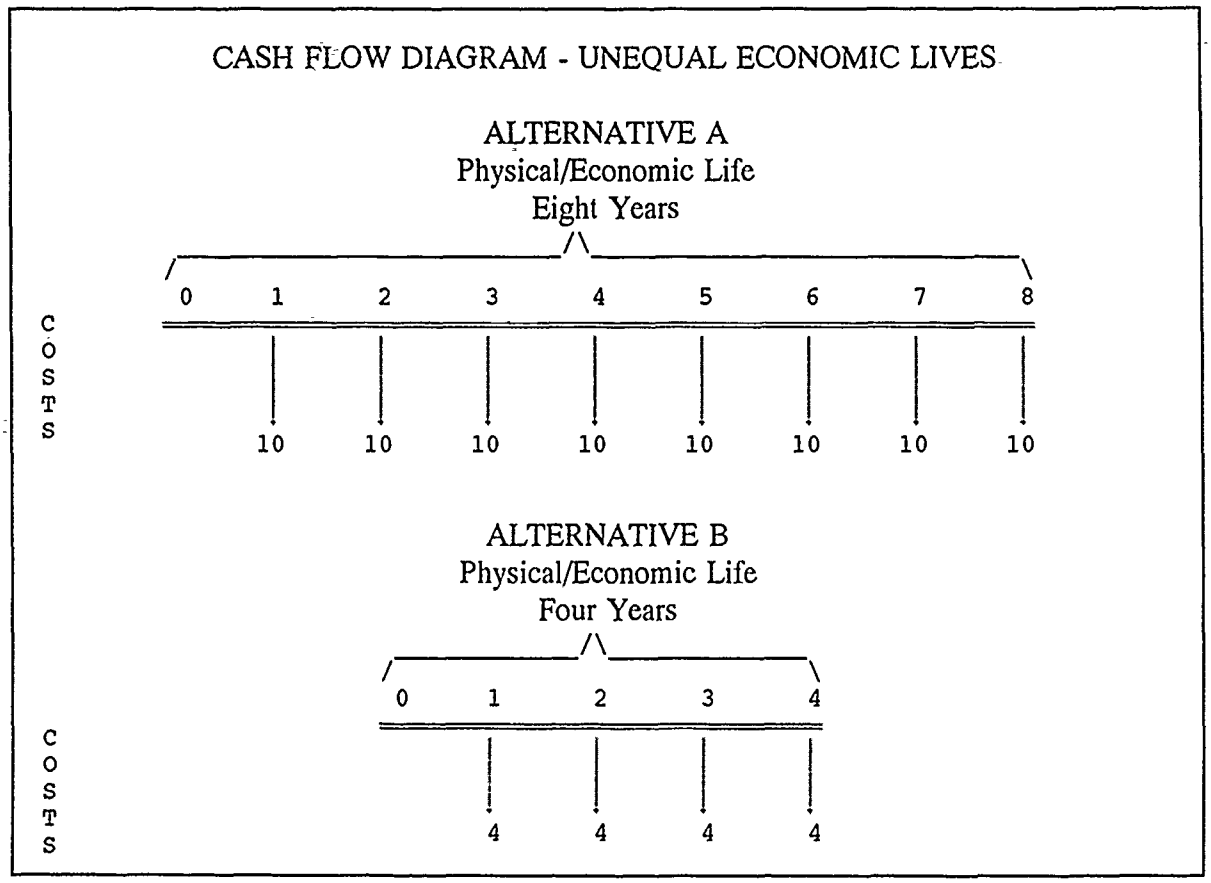


Figure 11-1

Which alternative should you select? While Alternative A costs more per year, Alternative A also provides benefits over a longer period. Remember, assumption two states that the requirement is open-ended. Applying assumption six allows you to use multiples of Alternative B. This gives a new cash flow diagram as figure 11-2 shows.

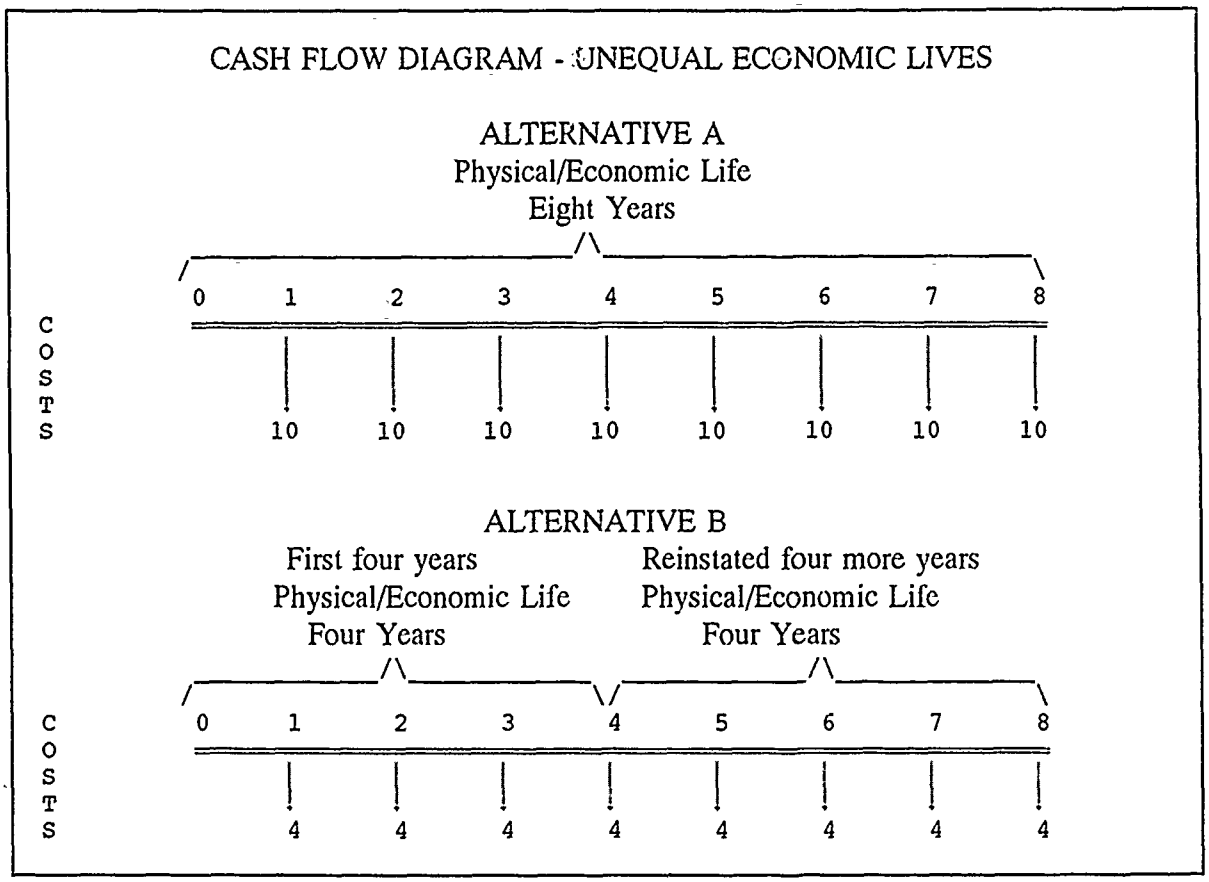


Figure 11-2

This strategy extends both alternatives to a common time. Noting assumption four, the alternatives yield comparable benefits per year, the extended alternatives provide equivalent levels of total benefits over the common 8-year period. From Figure 11-2, obviously Alternative B costs less. It requires a smaller expenditure in each year. On this basis, you would recommend Alternative B.

In reality, you could scarcely expect cash-flow patterns to be so simplistic. More likely, each alternative might have substantial but varying investment costs, unequal yearly cash flows, and perhaps, residual values in scrap.

A general unequal economic life situation might resemble that of figure 11-3. Here, the better economic choice is not obvious even if you know the costs and economic lives.

The Uniform Annual Cost technique converts each alternative into an equivalent hypothetical alternative having uniform recurring costs such as those in Figure 11-1. With the conversion, *the total net present value costs of the alternative and its hypothetical equivalent are the same.* Then, compare the hypothetical alternatives and identify the one with the least, net present value costs. Its corresponding actual alternative is the economic choice for the project.

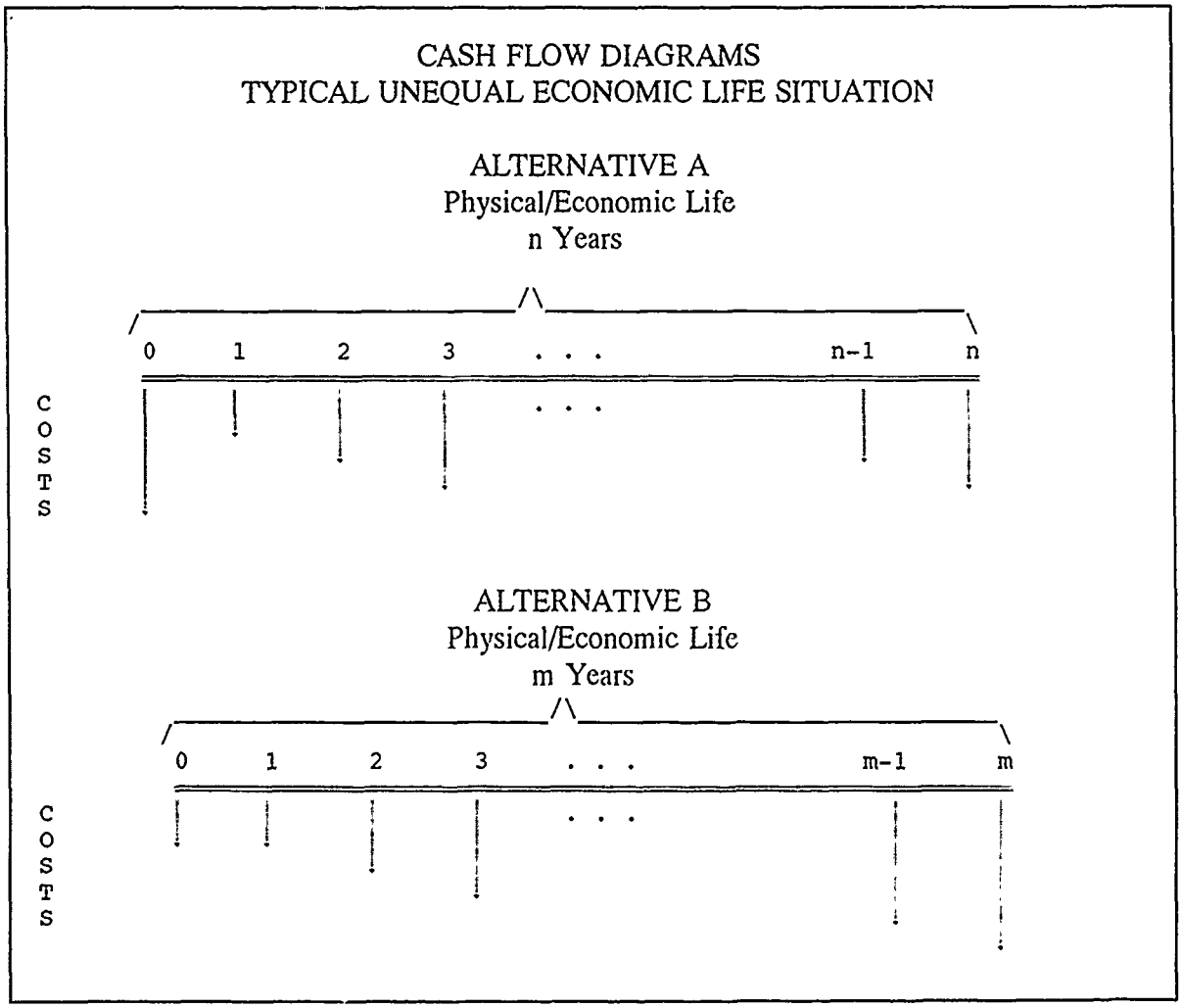


Figure 11-3

CALCULATION OF UAC

The analytical mechanism for calculating the UAC for an actual alternative is:

First, find the present value cost of the alternative. That is, find the sum of each year's discounted costs using a ten percent discount rate.

Second, divide the present value (PV) by the sum of the discount factors for the economic life of the alternative. Table C-1 of Appendix C provides cumulative discount factors. Thus, the formula for determining the Uniform Annual Cost becomes:

$$UAC = \frac{PV}{b_n}$$

where b_n represents the nth year Table C-1 factor.

The UAC represents the amount of money you would need in equal yearly installments to pay for the project.

Note, the UAC is different from taking a straight average. For example, a building with a 25-year life and an acquisition cost of $100 million has an average annual acquisition cost of $4 million. Using the technique of UAC, the annual cost is approximately $10 million.

Simple Average	UAC
$\frac{\$100M}{25} = \$4M$	$\frac{PV}{b_n} = \frac{\$100M}{9.524} = \$10M$

Using a simple average to find average annual cost for economic analysis purposes is inappropriate because it fails to acknowledge the time value of money. On the other hand, the UAC incorporates this idea in its formula. The significance of the $10 million uniform annual cost above is this: Were you to spend $10 million each year for 25 years, the total net present value of the payments would be $100 million, the same as the actual net PV cost of the alternative.

The financing of a new car provides a typical example of the use of the UAC idea. When purchasing a new car on time payments, the finance company will use the UAC idea to arrive at the amount and number of payments necessary to reduce the balance to zero. Since car payments usually are monthly, they base the payments on an equivalent monthly cost instead of equivalent annual cost. The payments will be higher than the simple arithmetic average due to interest charges. Thus, UAC is a type of average cost that includes interest costs.

Example 11-1

Suppose you will purchase new computers for your office. You are considering two equally effective alternatives and have collected the following information:

	Alternative A	Alternative B
Initial Cost	$325,000	$300,000
Operating Costs Year		
1	35,000	25,000
2	35,000	25,000
3	35,000	25,000
4	45,000	45,000
5	60,000	30,000
6	35,000	
7	35,000	
Service Life	7 years	5 years

Which is the more economical equipment to own and operate?

Solution

First, compute the PV cost for the alternatives. Your calculations are:

$PV_A = \$325 + 35\ (2.609) + \$45\ (.717) + \$60\ (.652) + \$35\ (5.108 - 3.977) = \underline{\$527}$

$PV_B = \$300 + \$25\ (2.609) + \$45\ (.717) + \$30\ (.652) = \underline{\$417}$

You then divide each PV by the cumulative present value factor corresponding to that alternative's economic life. The alternatives' uniform annual cost computations are:

Alternative A: $UAC_A = \dfrac{PV_A}{b_7} = \dfrac{\$527}{5.108} = \underline{\$103}$

Alternative B: $UAC_B = \dfrac{PV_B}{b_5} = \dfrac{\$417}{3.977} = \underline{\$105}$

Since Alternative A has the lower uniform annual costs, recommend it.

UAC AND LEAD TIME

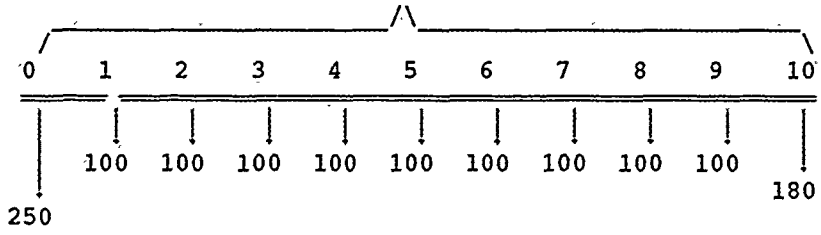
The UAC is a comparison of total cost per production year. When using the UAC technique, you should spread the cash flows over the *actual economic life only*. Treat costs you incur during lead time as investment costs. Consider the following:

Example 11-2

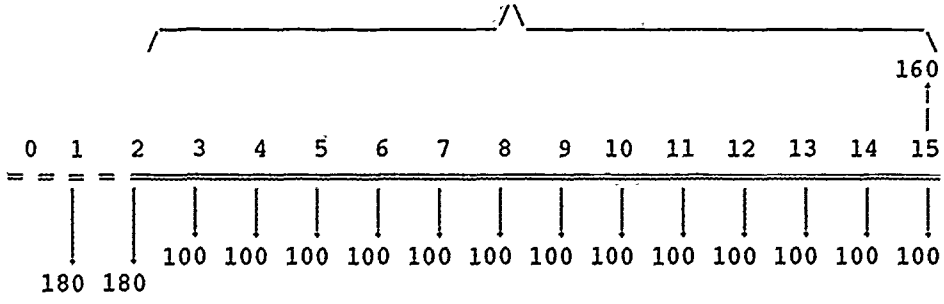
Suppose you must provide a digital data link to a National Guard unit training somewhere in the Middle East. You note that one option, Alternative A, offers immediate benefits. It has investment costs of $250K and an annual cost of $100K. The extra $80K in year ten is to dismantle and remove equipment.

Alternative B has two years of lead time (= = =) when you uniformly invest $360K. This is the total investment cost. The alternative does not become operational until the beginning of year three, at which point its economic life starts. You refer to the total 15-year period as the project life of the alternative. This alternative also requires an annual expenditure of $100K. The terminal value of the asset is $160K. Your cash flows are:

ALTERNATIVE A ECONOMIC LIFE



ALTERNATIVE B ECONOMIC LIFE



What are the Uniform Annual Costs?

Solution

Alternative A:

$$PV_A = \$250 + \$100(6.042) + \$180(0.405) = \underline{\$927}$$

$$UAC_A = \frac{\$927}{6.447} = \underline{\$144}$$

Alternative B:

$$PV_B = \$180(1.821) + \$100(7.980 - 1.821) - \$160(0.251) = \underline{\$904}$$

$$UAC_B = \frac{\$904}{7.980 - 1.821} = \frac{\$904}{6.159} = \underline{\$147}$$

In this example, Alternative A is economically preferable because it has the lower uniform annual cost.

NOTE: The economic life of Alternative B extends over a 13 year period (from the beginning of year 3 through the end of year 15). The equivalent uniform annual cost, $147, is that amount which, if paid annually from year 3 through year 15, would total $904 in today's dollars, the same as the PV of the actual alternative.

A generalization of this example's approach is: If an alterative has a project life of n years, of which the first m years are lead time and **not part of the economic life**, its uniform annual cost is:

$$UAC = \frac{PV}{b_n - b_m}$$

Had you mistakenly divided $904 by 7.980 (the 15-year cumulative present value factor), the UAC computation for Alternative B would have been $113. Since this is less than the UAC obtained for Alternative A, you would erroneously conclude that Alternative B is preferable.

SUMMARY

Uniform Annual Cost is an economic analysis technique comparing two or more alternatives having different lives. The technique converts a stream of expenditures over several years to a constant amount for each year in the time frame. Calculation of the UAC involves dividing the present value of the alternative by the cumulative discount factor associated with its economic life. This accounts for the time value of money. Thus, the analysis does not reflect actual cash outlays. Instead, you use the analysis for comparison purposes as part of the

CHAPTER 12

SAVINGS/INVESTMENT RATIO

INTRODUCTION

A Savings/Investment Ratio (SIR) is the relationship between *future cost savings and the investment necessary to those obtain savings.* A SIR of 1 shows that the present value (PV) of the savings is equal to the PV of the investment. For an investment to be economically sound, the SIR must be greater than one.

Notice that this discussion does not mention benefits. The SIR is a characteristic of costs only. You use it to analyze individual investments or to rank competing investment projects.

COMPUTATION OF SIR

To understand the idea of SIR, consider Figure 12-1. Cash flow Diagram A depicts the *status quo*, Diagram B a *proposed alternative*. Both extend over an economic life of *n* years.

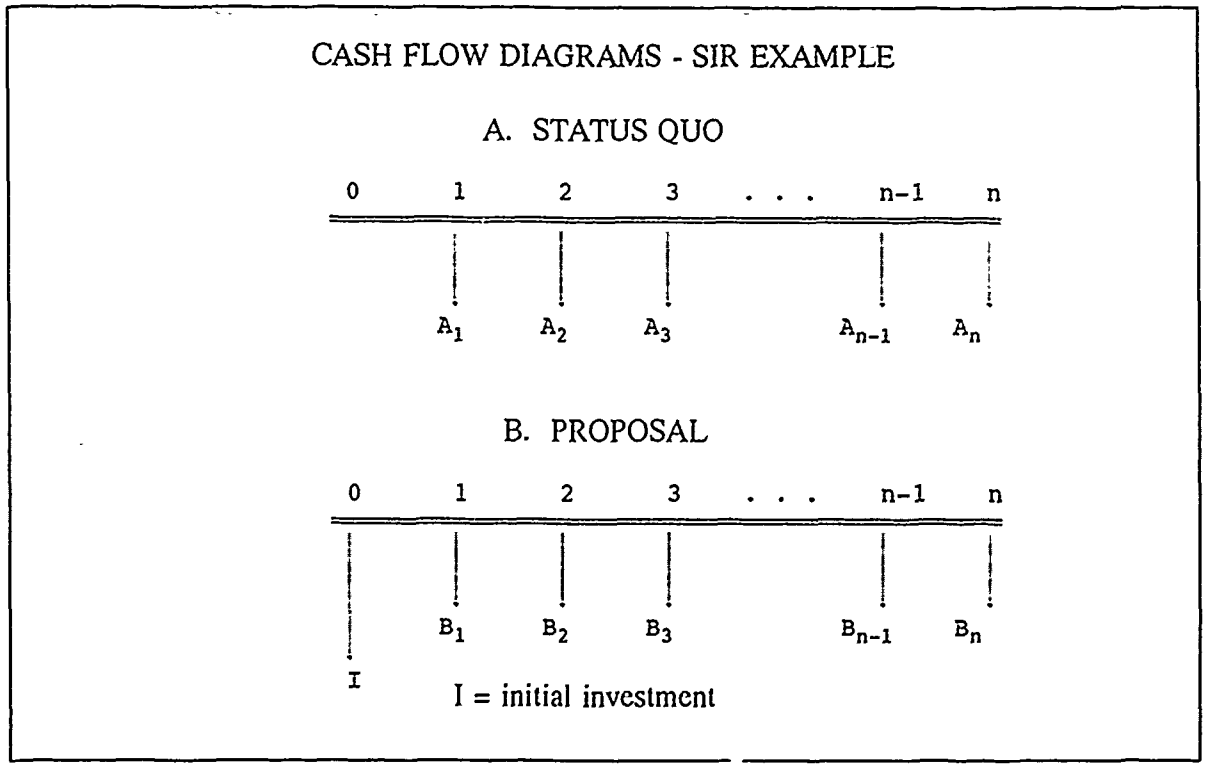


Figure 12-1

When computing an SIR, your interest is *not* in total operating costs. Instead, you're interested in the *difference* between life cycle operating costs for *two alternatives*. The difference is the effect the investment has on the operation. Thus, the crucial question in Figure 12-1 is: Do the recurring savings of B compared to A warrant the investment I? Savings is the amount of annual expenditure you were incurring but a proposed alternative reduces.

In Figure 12-1, the total PV savings (PV_S) of Alternative B compared to A are:

$$PV_S = PV(A_1 - B_1) + PV(A_2 - B_2) + \ldots + PV(A_n - B_n)$$

The savings/investment ratio is:

$$SIR = \frac{PV_S}{I}$$

You should not initiate Alternative B unless its SIR exceeds unity. That is, unless its future discounted savings more than offset its discounted investment cost.

REFINEMENT OF SIR

The SIR in figure 12-1 captures the essence of the savings/investment ratio idea. To refine the SIR further, closely examine the nature and timing of the cost elements involved. For example, if the initial investment I associated with Alternative B extends beyond one year, put the total present value of I into the SIR, yielding:

$$SIR = \frac{PV_S}{PV_I}$$

If Alternative B also includes a terminal value T, use the present value of the investment I less the terminal value T.

$$SIR = \frac{PV_S}{PV_I - PV_T}$$

The presence of other cost elements, such as the value of assets replaced or a refurbishment cost to sustain the status quo would require that you further refine the SIR formula.

Example 12-1

Suppose you consider purchasing a numerically controlled cutting machine. The initial investment is $25,000. You anticipate that this machine will *reduce* **operating costs $6,000 per year** during its 8 years of operation. Salvage value after 8 years is $5,000. Is this an economical investment?

Solution

Figure 12-2 depicts a single cash flow showing the difference between a proposed alternative and the status quo.

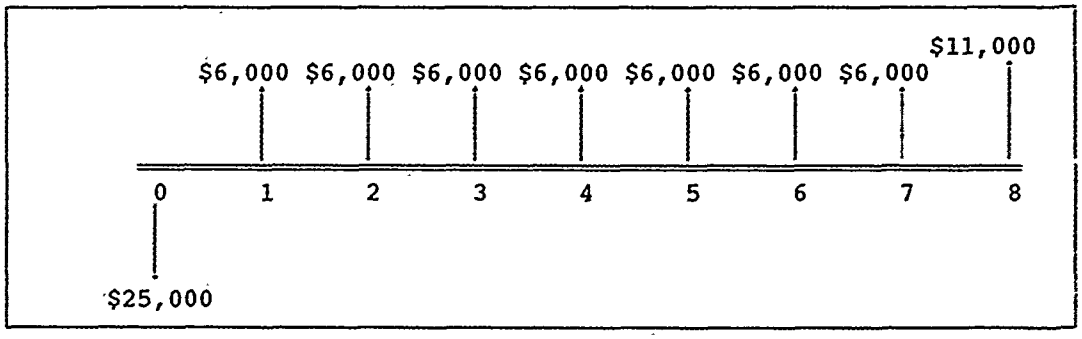


Figure 12-2

To calculate the SIR, you figure out the ratio of the present value of the savings to the present value of the investment less the present value of the terminal value:

$$SIR = \frac{PV_S}{PV_I - PV_T}$$

$$= \frac{\$6{,}000(5.597)}{\$25{,}000 - \$5{,}000(.489)}$$

$$= \underline{1.49}$$

Since the SIR is greater than 1.0, the investment is economically sound. That is, the present value of the cutting machine savings exceeds the present value of its cost.

COMPARING COMPETING INVESTMENT PROJECTS

The SIR reflects the savings that result from each dollar you invest. As the SIR becomes greater, the investment becomes more profitable. For example, an investment with a SIR of 1.25 is more profitable than an investment with a SIR of 1.10. It yields 15 cents more savings for each dollar you invest.

The Government does not base decisions to fund projects solely on economics. Benefits, which the SIR does not consider, also play an important role. Still, if you disregard benefits and assume that several investment programs are equally worthwhile, then the SIR technique is a valid decision tool for setting priorities among investment projects.

Example 12-2

Suppose you budget $1200K for new investment projects. You identify four projects you consider equally worthwhile for possible funding. Given the following information, decide which projects should receive funding.

Projects	Initial Investment	Annual Savings	Economic Life
1) Upgrade ADP	$600K	$150K	6 years
2) Implement Inventory Accounting Systems	600K	125K	8 years
3) Mechanize Warehouses System	300K	60K	10 years
4) Acquire Better Material Handling Equipment	300K	80K	6 years

Solution

The SIR of each project is:

1) Upgrade ADPE: $SIR = \frac{PV_S}{PV_I} = \frac{150(4.570)}{600} = \underline{1.14}$

2) Inventory Accounting System: $SIR = \frac{PV_S}{PV_I} = \frac{125(5.597)}{600} = \underline{1.17}$

3) Mechanize Warehouses: $SIR = \frac{PV_S}{PV_I} = \frac{60(6.447)}{300} = \underline{1.29}$

4) Material Handling Equipment: $SIR = \frac{PV_S}{PV_I} = \frac{80(4.570)}{300} = \underline{1.22}$

All four projects are cost effective since each has an SIR greater than one. However, because of the $1200K budget constraint, you only fund projects with the greatest SIRs. You select the projects in this order:

SIR	Project	Amount Invested	Remaining Funds
1.29	3	300K	900K
1.22	4	300K	600K
1.17	2	600K	0
1.14	1	*	0

*You won't do this project as the others use all the funds.

USING SIRS IN ECONOMIC ANALYSES

You can use the SIR technique to set priorities among various unrelated projects. Generally, with limited funds, you initiate projects with the highest SIRs. But, in an economic analysis, you have a single project with alternative ways of doing it. While you compare and rank several alternatives against each other, you select only one, the least costly alternative.

The SIR relates a proposed alternative to its status quo. When a project has more than one alternative, the SIR technique will find which one produces the most savings per dollar invested. As it turns out, the alternative with the greatest SIR also has the lowest present value costs. Example 12-3 shows how you can use the SIR to compare alternatives.

Example 12-3

Suppose the operating costs at your data processing installation ***increase*** each year because of high maintenance costs on your equipment and the high personnel costs associated with operating the equipment. You develop a plan to expand the installation and replace the existing equipment. If the expansion takes place, you will eliminate current plans to modify and refurbish the computer room 2 1/2 years from now. Your plan requires a ***one year lead time*** for site preparation and system development *before the system becomes operational.* You estimate the economic life to be five years. Given the following cost data which alternative would you choose?

	ADPE Replacement		
Cost Element	Status Quo	Purchase	Lease*
One-time:			
ADPE Purchase	0	4000	0
Site Preparation	0	1200	1200
System Development	0	800	800
Replace Existing ADPE	0	(1300)	(1300)
Refurbish Computer Room	500	0	0
Terminal Value of ADPE	(130)	(400)	0
Recurring:			
ADPE Rental	0	0	1700
ADPE Maintenance	1500	1000	700
Personnel	5000	3000	3000
Economic Life	5 years	5 years	5 years

*Use this as an investment, even if you pay for it each year.

Solution

To compute the SIRs for the Purchase and Lease Alternatives, you modify the SIR formula to be:

$$SIR = \frac{PV_S + PV_R}{PV_I - PV_T}$$

Where:

S = Savings
I = Initial investment less the value of existing assets replaced.
R = Refurbishment eliminated
T = Terminal value of investment

$$\text{Thus, SIR (Purchase)} = \frac{3.616\ (\$2500) + .788\ (\$500)}{.954\ (\$4700) - .592\ (\$400)} = 2.22$$

$$\text{SIR (Lease)} = \frac{3.616\ (\$2800) + .788\ (\$500)}{(.954(\$700) + 3.616(\$1700)) - 0} = 1.54$$

The purchase alternative has a higher SIR and appears to be less costly. To discover if this is true you could evaluate each alternative and the status quo using the present value technique.

PV Status Quo = .788 ($500) + 3.616 ($1500 + $5000) - .592(5130) = $394 + $23,504 - $77
= $23,821

PV Purchase = .954 ($4000 + $1200 + $800 - $1300) - .592 ($400) + 3.616 ($1000 + $3000)
= $4484 - $237 + $14,464
= $18,711

PV Lease = .954($1200 + $800 - $1300) + 3.616($1700 + $700 + $ 3000)
= $668 + $19,526
= $20,194

The results of the PV Analysis show the Purchase Alternative is the least cost alternative.

CHAPTER 13

DISCOUNTED PAYBACK ANALYSIS

INTRODUCTION

Probably, the most widely understood method for comparing alternative investments (or for evaluating a single investment) is "payback" analysis. Payback is the period a project's accumulated savings require to offset its investment costs. Thus, a project costing $100 yielding annual savings of $25 would have a four-year payback period. You use Discounted Payback Analysis when the speed of investment recovery is critical.

Note that the duration of a project's life does not alter the economic connotation of payback. A 4.5 year payback is the same whether the economic life is 10 or 25 years.

DISCOUNTED PAYBACK ANALYSIS

This introduction's example has two major shortcomings that you may have noted.

First, the four year payback represents a *payback without discounting*. By failing to recognize the timing of cash flows within a project payoff period, this payback ignores an important element, the *time value of money*. For example, a project costing $350,000 that will return $50,000 per year for 10 years appears to be a good investment. The return will be $500,000. The project will amortize itself in seven years. Yet, applying a ten percent discount factor over the full 10 years yields present value savings of only $322,350. Thus, such a return would not adequately cover investment costs.

Second, the conventional notion of payback analysis fails to address cash flows beyond a period necessary to recover initial investment costs. If significant one-time costs *occur after* the estimated point of payback, such as for a major repair or overhaul, you overstate the attractiveness of the project.

By incorporating a time value element and including all future cash flows, you can modify the payback period idea to find the *discounted payback period.* Thus, a project makes its payback when *accumulated present value savings* are sufficient to offset, or amortize the *total present value costs* of a proposed alternative. The payback period is simply the time between the point of initial investment and the point at which payback occurs. As noted in Chapter 2, since savings are a necessary factor for computing payback, you use this technique when you can *compare your alternative to the status quo.*

This differs from the private sector that makes its payback when profits offset investment. Thus, they can compute payback even when they don't know the status quo. Since the Government is not in the business to make a profit, this limits using the payback technique if you don't know the status quo.

Example 13-1

Suppose preliminary studies show that a new printer will save your office $1,500 annually. The cost of the printer is $5,000 and during the fifth year it will require significant maintenance costing $3,000. The printer has an economic life of eight years and a terminal value of $500. Find the discounted payback period for the equipment.

Solution

The present value less terminal value of the equipment is:

$$PV_I - PV_T = \$5000 + .652\ (\$3000) - .489\ (\$500) = \underline{\$6712}$$

$$PV_S = \$1500\ (5.60) = \underline{\$8400}$$

Where:

PV_I is the present value of your investment.
PV_T is the present value of its terminal value.
PV_S is the present value of your savings.

Since total life-cycle savings of $8,400 are greater than the investment cost, the proposed alternative is economical and you should implement it. The project will recoup total investment costs when $PV_S = PV_I - PV_T$, in approximately six years.

To find the exact point of payback, use interpolation. First subtract year 5 Cumulative PV_S from the PV_I ($6,712 -($1500 * 3.977) = $745). This is the discounted dollar value of savings that attribute to payback. Next, divide this amount by the total PV(S) for year 6 to find the proportion of that year during which the savings payback the investment ($745/$888 =.839). Thus, the "discounted payback" is 5.8 years.

NOTE: The cumulative discount factor computed above corresponds to the period during which the alternative is accruing savings, that is, during its economic life. When an alternative has lead time, you must add the lead time to adjust the cumulative factor.

ADVANTAGES OF PAYBACK

The discounted payback period lets you know exactly how long it will take to recoup costs. Alternatives with short payback periods cut the risks that unforeseen events will stop them from recouping their costs. For example, changing technology could suddenly render your system obsolete and insupportable long before payback occurs.

DISADVANTAGES OF PAYBACK

Payback has several disadvantages. First, payback favors alternatives having low investment costs and high earnings. Next, payback provides no means of comparing lease-versus-buy alternatives, since the lease may require no initial investment cost. This of course would yield a zero payback period despite the length of the leasing contract. Finally, payback will not necessarily identify the least costly alternative; it merely identifies the time when the alternative recoups the total investment costs. Payback fails to consider those additional savings that occur beyond the payback period.

Example 13-2

Suppose you evaluate two ways to automate a manual task against the present system. You spread the initial investment costs for the proposed alternatives *uniformly over a two-year lead time.* The system will be operational in year 3. Find the payback period for each alternative. Life cycle costs are:

Cost Category	Status Quo	Alternative 1	Alternative 2
Initial Investment	0	$8,000	$15,000
Annual Operating Cost	$12,000	9,000	7,000
Terminal Value	0	800	1,500
Economic Life	8 years	8 years	8 years

Solution

Compute the payback periods for the alternative:

1. Determine cumulative factors according to economic life.

Alternative 1: $$\frac{PV_I - PV_T}{\text{Annual Savings}} = \frac{1.821(\$4000) - .405\ (\$800)}{\$3000} = 2.320$$

Alternative 2: $$\frac{PV_I - PV_T}{\text{Annual Savings}} = \frac{1.821\ (\$7500 - .405\ (\$1500)}{\$5000} = 2.610$$

2. Adjust for lead time by adding two year factor.

Alternative 1: 2.320 + 1.821 = 4.141
Alternative 2: 2.610 + 1.821 = 4.431

By comparing these values to Table C-1 discount factors, discounted payback occurs in year 6 for Alternative 1 and 2. NOTE: This does not imply that Alternative 1 is the least costly alternative. To determine the least costly alternative, you calculate the net present values for the alternatives as follows:

$PV_{\text{Status Quo}}$ = 4.626 ($12,000) = $55,512

$PV_{\text{Alternative 1}}$ = 1.821($4000) + 4.626 ($9000) -.405 ($800) = $48,594

$PV_{\text{Alternative 2}}$ = 1.821 ($7500) + 4.626 ($7000) - .405 ($1500) = $45,433

CHAPTER 14

BREAK-EVEN ANALYSIS

INTRODUCTION

Break-even analysis is an important analytical technique used to study the relationship between alternative cost patterns. In break-even analysis, you want to find the value of a variable, the "break-even point," where you're indifferent between two possible courses of action. At the break-even point, the economic desirability of the two alternatives is equal. To either side of the break-even point, one alternative or the other has the economic advantage.

BREAK-EVEN CHART

Figure 14-1, a basic break-even chart, depicts the nature of break-even analysis. The horizontal axis measures time in yearly intervals. Still, you could use any other convenient and meaningful measurement, such as the number of units produced or hours of machine operation. The vertical axis measures dollars. The curves measure the discounted life cycle cost patterns for each alternative. The intersection of the two cost curves determines the break-even point. Here, it occurs during year four. To the left of the point the cumulative cost for Alternative 2 is less than for Alternative 1. At the break-even point the costs are equal. To the right, the cumulative cost of Alternative 1 is less than Alternative 2.

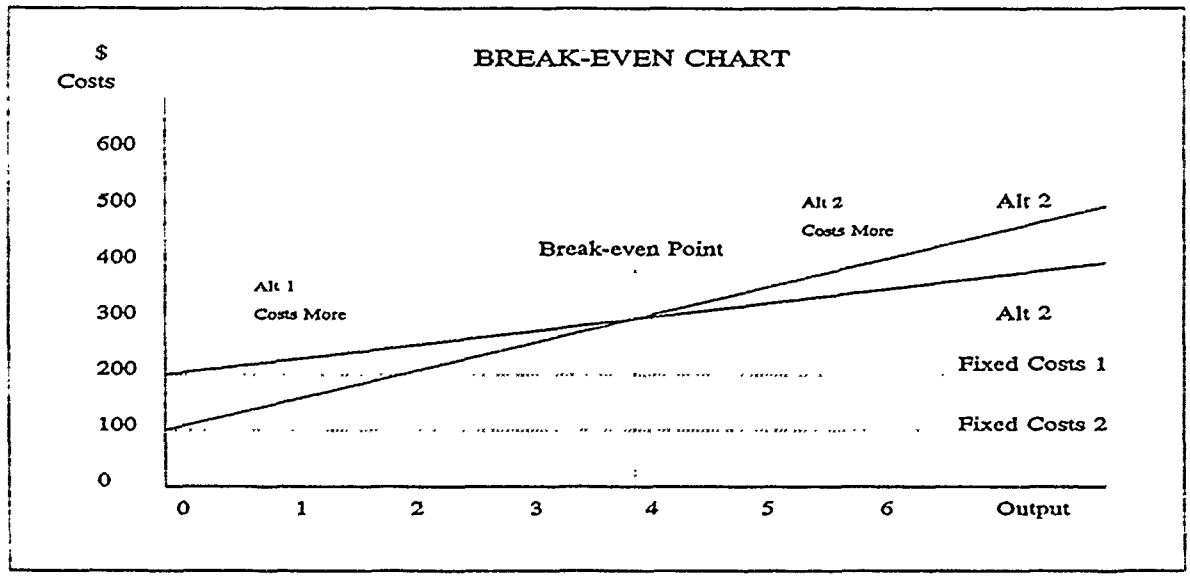


Figure 14-1

Break-even charts are useful in economic analyses because they provide you with the capability to compare alternatives visually at any time or output. They are convenient, effective, readily accepted and easily understood.

BREAK-EVEN ANALYSIS AND VARIABLE OPERATING COSTS

Break-even analysis is useful for analyzing the financial characteristics of an alternative based upon some variable such as the number of units produced, the number of hours of machine operation, or the quantity of packages handled. The analysis focuses on how total costs vary with output as operations become automated or mechanized, substituting fixed for variable costs.

Example 14-1

Suppose you're selecting between two types of printers. Each has a certain cost of setting up the equipment for production. Additionally, each has a charge for every page it produces. Given the following cost data, find the job size that represents the break-even point for the alternatives:

Costs	Printer A	Printer B
Set up costs	$2.00	$3.50
Unit cost per page	.015	.010

Solution

Figure 14-2 depicts the break-even analysis. The vertical axis is dollars per job while the horizontal axis is pages per job. The curves represent the costs for each machine. The cost for Printer A is below the cost for Printer B when the jobs have fewer than three hundred pages. When a job requires more than three hundred pages, Printer B is cheaper. Of course, if the job requires exactly three hundred pages then the two machines have the same costs.

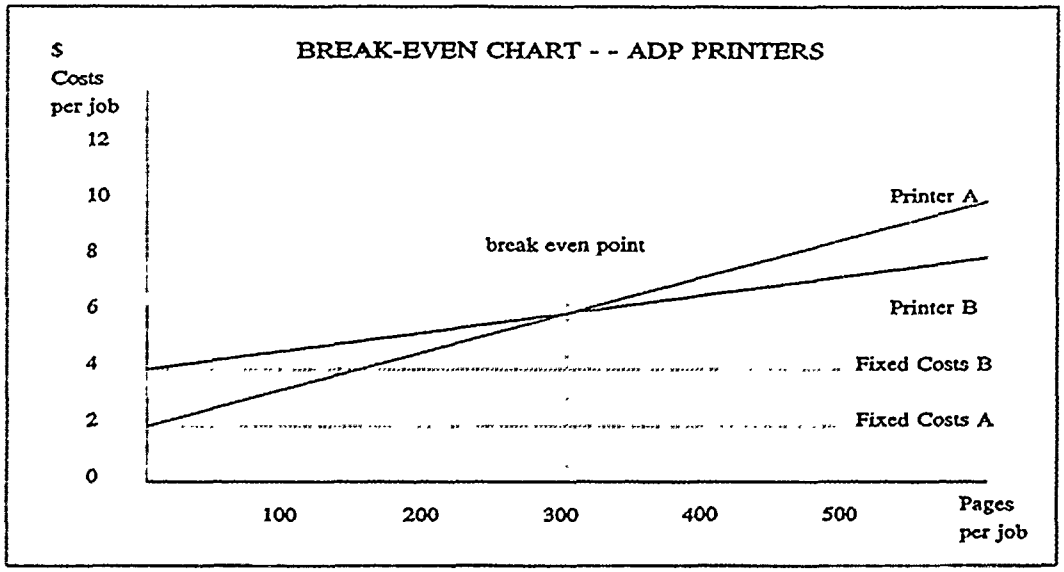


Figure 14-2

ALGEBRAIC BREAK-EVEN ANALYSIS

(Solution Continued)

Although break-even charts are a useful to illustrate cost relationships, algebraic techniques typically are more efficient for analyzing decision problems. The algebraic technique for solving a break-even problem sets the cost equations for each alternative equal and solving the unknown.

The general cost equation is: TC = FC + VC(x) where:

TC = Total cost FC = Fixed cost
VC = Variable cost x = Unknown break-even point

The two equations for Example 14-1 become:

$$TC\ (\text{Printer A}) = \$2.00 + \$.015x$$
$$TC\ (\text{Printer B}) = \$3.50 + \$.010x$$

Setting them equal and solving for x gives:

$$\$2.00 + \$.015x = \$3.50 + \$.010x$$
$$\$.005x = \$1.50$$
$$x = \underline{300}$$

Thus, the break-even point is three hundred pages.

INCORPORATING PRESENT VALUE OF CASH FLOWS

Given that you compare the alternatives during the same period, or the cash flows are equal throughout all periods, you do not need to include present value analysis. On the other hand, if you have varying cash flows, or an initial investment, you must convert your cash flows into their present values. Then complete your break-even analysis.

Example 14-2

Currently, a commercial timesharing service provides ADP support in your office. The only equipment used is a CRT you rent for $1800 per year. The timesharing company bills variable usage fees based solely on connect time at a rate of $21 per hour. As you will soon increase the size of your staff, you expect the usage of the system to increase, too. For $50,000, with an annual maintenance cost of $5,000, you could purchase a minicomputer and all software to make it comparable to the timesharing services. If the life of the mini is 5 years, find the number of hours per year you must use the equipment to make the investment worthwhile.

Solution

The choice of alternatives depends upon the number of hours per year you will use the computer. The variable "x" represents the hours of annual usage. The cash flow diagrams are:

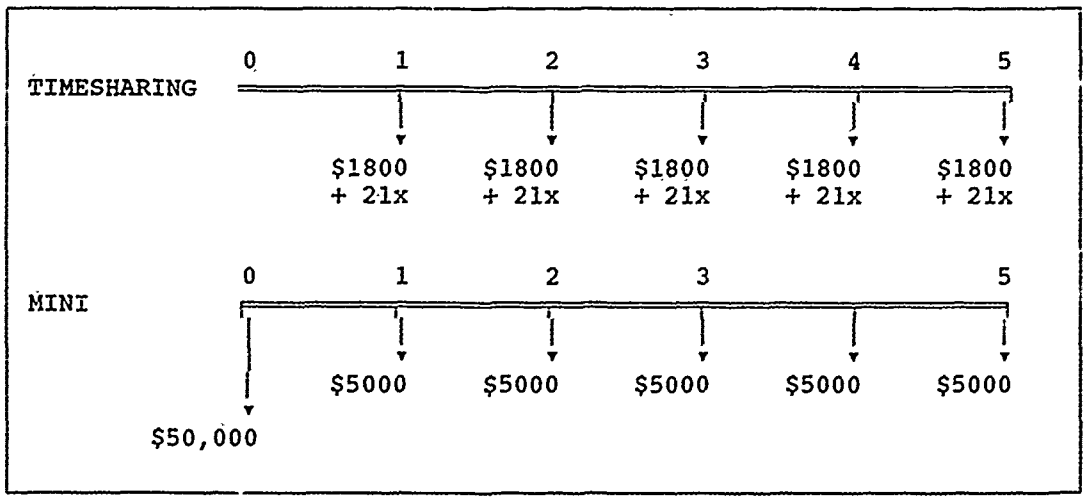


Figure 14-3

(Solution Continued)

The present values for the two alternatives are:

$$\text{PV (Timesharing)} = (\$1800 + \$21x)\,3.977$$
$$= \underline{\$7158.60 + \$83.50x}$$

$$\text{PV (Mini)} = \$50{,}000 + (\$5000 * 3.977)$$
$$= \underline{\$69{,}885}$$

To find the break-even points, set the two PVs equal and solve for "x":

$$\text{PV (timesharing)} = \text{PV (Mini)}$$

$$\$7158.60 + \$83.52x = \$69{,}885$$

$$\$83.52x = \$62{,}726.40$$

$$x = \underline{751 \text{ hours}}$$

Thus, using the equipment 751 hours per year results in the same costs for both alternatives. If you use the equipment more than 751 hours per year, investment in the mini is worthwhile. If you use less than 751 hours, commercial timesharing service is the most economical alternative.

With this information, you do not need to have a fixed estimate of future use. Your concerned is whether the usage will be more or less than 751 hours per year. The break-even technique points out that, as your usage nears 751 hours, the solutions are nearly equitable. However, when usage falls outside of this point, break-even analyses simplifies your selection of an alternative.

CHAPTER 15

BENEFIT COST RATIOS

INTRODUCTION

So far, you have considered techniques to compare only the cost of alternatives. These techniques are useful if benefits associated with all alternatives are comparable. Still, you will discover many instances when the assumption of equivalent benefits is a poor one. Therefore, you must devise some method to compare both the costs and the benefits of alternatives. The Benefit Cost Ratio (BCR) is an accepted and recommended method.

BENEFIT COST RATIO

One thing to consider when evaluating a possible investment is whether it will yield benefits commensurate with the costs. To find the economic desirability of an investment you *divide the benefits by the costs*, calculating the BCR. This gives you a single number or value for the investment. *This value represents the amount of benefits obtained per unit of cost.*

You compute a separate BCR for each alternative. The alternative with *the highest BCR is the most cost effective.* That is, it returns the most benefits for each dollar spent. The method of computing the BCR will vary from analysis to analysis depending upon the number of benefits involved and whether the benefits are quantifiable. In all cases, since you spread costs over a designated period, you must account for the time value of money in the calculation.

BCR AND QUANTIFIABLE BENEFITS

Many projects have a stated goal defined in terms of required output, such as, to reduce errors, to decrease response time, or to process an increased workload. The goal is not always quantified, but it often is susceptible to quantification and thus provides a potential measure of benefits associated with the project.

When you can quantify output, the appropriate formula for the BCR is:

$$BCR = \frac{\text{Quantifiable Output Measure}}{\text{Uniform Annual Cost}}$$

In this expression, you calculate the Uniform Annual Costs (UAC) as Chapter 11 described. You use the UAC in the calculation because it accounts for both the time value of money and that the alternatives often have different economic lives. The quantifiable output measure is a statement of expected output over some designated period for the alternative under investigation. You should not attach significance to computed BCR being less than unity. This is due entirely to the dimensional quality of the BCR and the arbitrarily chosen baseline, such as, cards punched per minute versus cards punched per hour. The only valid comparison is between the two ratio

measures. Their relationship to unity lacks significance. Do not confuse this with the savings investment ratio where the effect of unity is crucial.

Some examples of quantifiable output measures are:

1. Number of pages printed per hour
2. Number of reports generated per week
3. Number of work orders processed per month
4. Number of transactions recorded per minute
5. Decreased error rate per job

This list is not exhaustive, but it should give you with a good perception of the measure and help you formulate other measures tailored to your particular problem. *Note, you already account for savings in the cost analysis. You should not count them again as an output measure.*

When using this technique, you should use the most significant output factor to compute the BCR. When you have several significant factors, you may compute a BCR for each.

Example 15-1

Suppose you periodically review government contractors to assure that they comply with equal opportunity standards. Currently, you use a manual process to collect, analyze and maintain this data. You should review each contractor annually. Yet, because the manual process is slow and tedious, you review only 23% of the workload, 39,000 reviews per year. An automated information system could double the number of reviews performed by reducing much of the manual effort dedicated to scheduling reviews and generating follow-up reports. Costs for the two alternatives are:

Cost Category	Manual Alternative	Automated Alternative
One-time (year 1)	0	$2,175,000
Recurring (years 2-9)	$1,650,000	$2,050,000

Using the annual number of reviews as a measure of benefits, find the BCR for each alternative.

Solution

You compute a BCR for the manual and automated systems using the following formula:

$$BCR = \frac{\text{Quantifiable Output Measure}}{\text{Uniform Annual Cost}}$$

The quantifiable output measures for the automated and manual systems are 78,000 and 39,000, respectively. Using the uniform annual cost formula developed in Chapter 11, you compute the UAC to be:

$$UAC = \frac{PV}{b_n - b_m}$$

$$UAC\ (Automated) = \frac{\$2{,}175{,}000(.954) + \$2{,}050{,}000(6.042-.954)}{6.042 - .954}$$

$$= \frac{\$2{,}074{,}950 + \$10{,}430{,}400}{5.088}$$

$$= \underline{\$2{,}457{,}812}$$

$$UAC\ (Manual) = \frac{\$1{,}650{,}000(6.042 - .954)}{6.042 - .954}$$

$$= \frac{\$8{,}395{,}200}{5.088}$$

$$= \underline{\$1{,}650{,}000}$$

Substitute the quantifiable output measures and the UAC into the BCR formula and get:

$$BCR\ (Automated) = \frac{78{,}000}{\$2{,}457{,}812} = \underline{.032}$$

$$BCR\ (Manual) = \frac{39{,}000}{\$1{,}650{,}000} = \underline{.024}$$

The proposed automated system has a higher BCR than the current manual system. Therefore, it is the more cost-effective alternative.

BCR AND NON-QUANTIFIABLE BENEFITS

Even when you can't quantify benefits, you can still use the BCR technique by calculating an Aggregate Benefit Value (ABV). To do so, you identify factors within the alternatives that are important to your decision. Next, you assign weights to the factors to establish their relative importance to one another. Then, based on the decision factors, you rank each alternative on a scale of 0 to 10, where 0 means "of no value" and 10 represents an "attainable ideal." Lastly, you multiply the ranking of each factor by the factor weight and sum the results. This is the ABV. You use this in lieu of a benefit.

Table 15-1 illustrates one possible approach for developing an aggregate benefit value.

TABLE 15-1

BENEFITS RANKING -- AUTOMATED

Decision Factor	Factor Weight	Ranking	Product
Data availability	3	9	27
Data timeliness	2	8	16
Data accuracy	2	6	12
Decision making	3	9	27
Summation			82
UAC			2.46
BCR			33.36

BENEFITS RANKING -- MANUAL

Decision Factor	Factor Weight	Ranking	Product
Data availability	3	7	21
Data timeliness	2	10	20
Data accuracy	2	7	14
Decision making	3	8	24
Summation			79
UAC			1.65
BCR			47.88

Example 15-2

Suppose that you must rate the system in example 15-1 but you do not have the benefit data. Instead, your boss told you his concerns about data availability and how well the system will support the decision making process. He is less concerned about the system's timeliness and accuracy, although they're important. What is the BCR?

Solution

First, you identify factors within the alternatives that are important to your decision. Remembering what your boss said, you decide that data availability and how well the system will support the decision making process are important and that the system's timeliness and accuracy are somewhat less so.

Next, you assign weights to the factors to establish their relative importance to one another. You decide that data availability and how well the system will support the decision making process will have a weight of three and that the system's timeliness and accuracy will have a weight of two.

Then, based on the decision factors, you rank the decision factors for each alternative on a scale of 0 to 10, where 0 means "of no value" and 10 represents an "attainable ideal". For the automated alternative, you decide it rates a 9 for data availability, a 9 for supporting the decision making process, an 8 for timeliness and a 6 for accuracy. For the manual alternative, you decide it rates a 7 for data availability, a 8 for supporting the decision making process, 10 for its timeliness and 7 for its accuracy.

Lastly, you multiply the ranking of each factor by the factor weight and sum the results. Your calculations are:

Automated $(3 \times 9) + (2 \times 8) + (2 \times 6) + (3 \times 9) = \underline{82}$
Manual $(3 \times 7) + (3 \times 8) + (2 \times 7) + (3 \times 10) = \underline{79}$

From example 15-1, the UAC is $2,457,812 for the automated alternative and $1,650,000 for the manual alternative. Dividing the aggregate benefit values by the UACs provides the BCR for each alternative. Your calculations are:

$$\text{BCR Automated} = \frac{82}{\$2.458\text{M}} = \underline{33.36}$$

$$\text{BCR Manual} = \frac{79}{\$1.650\text{M}} = \underline{47.88}$$

Thus, the manual alternative yields a higher return per dollar spent.

PART V - SENSITIVITY ANALYSIS

CHAPTER 16

UNCERTAINTY

INTRODUCTION

Depending upon the amount of information or the number of facts available, while performing an economic analysis, you will find yourself in one of two environments: "certainty" or "uncertainty." Under certainty, you understand all facts, actions and results. Under uncertainty, you do not know all the facts. You must make various assumptions to create a workable environment. When uncertainties exist in an analysis, you must carefully examine each to find its influence on your final recommendation.

CERTAINTY

The ideal environment for decision making is one where you know all things: You have no doubt, no uncertainty. You know exactly what will happen, when it will happen, and all other related aspects. You need no formulation of assumptions, step two in the economic analysis process, because you know everything. Obviously, you seldom, if ever, encounter this type of environment.

UNCERTAINTY

The estimates of costs and benefits considered so far are average, predicted, or expected outcomes. But, you know that for all sorts of reasons, these amounts may be off the mark. The actual costs of development or production never coincide exactly with advance estimates. This is not because you are lazy or careless in your estimate. Instead, the inherent uncertainty surrounding the current and future environment causes the difference. The most common uncertainties are:

Uncertainty about planning and cost factors. Every model uses as inputs certain relations between its elements. These are planning factors. For example, planning factors are the time it takes to perform a certain function, the number of people required to do a given workload, the amount of CPU time required to run a particular program. Planning factors are the main ingredient in estimating costs. Because you cannot always predict this information with complete accuracy, uncertainty will exist in the analysis.

Requirements Uncertainty. Requirements uncertainty has to do with variations stemming from changes in the system you're analyzing. When you conceive a new system, its preliminary design seldom turns out to be the same as the final design. Changes will take place in the requirements and characteristics of the system. Requirements change for economic, political, technological, and environmental reasons. Estimates for systems' costs historically relied upon the preliminary design information. If the preliminary characteristics of the system are in error, then early cost estimates relying upon those characteristics will be in error.

Technological Uncertainty. Technological uncertainty deals with the likelihood that the system cannot get the desired output. Technological uncertainty rarely is a serious problem in analyses of current operational problems. Still, as you try to peer further into the future, technological uncertainty becomes more important and can dominate your analysis. Technological uncertainty is central in research and development decisions.

Statistical Uncertainty. Statistical uncertainty results from the chance element in recurring events. This is the uncertainty that persists even if you could predict the values of important parameters. For example, if you flip a penny a thousand times, it will come down heads about half the time. But if you flip it only ten times, the proportion of heads may be very different. Given the impact of requirements uncertainty and technological uncertainty, statistical uncertainty is insignificant.

TREATMENT OF UNCERTAINTY

Now that you know that uncertainty does exist in economic analyses, what do you do about it? The most important advice is: Don't ignore it. To base an analysis and decision on some single set of best guesses could be disastrous. For example, suppose you are uncertain about ten factors and you make a best guess on all ten. If the probability that each best guess is 60 percent, the probability that *all* ten are right is about one-half of one percent (.6 x .6 x .6 x .6 x .6 x .6 x .6 x .6 x .6 x .6). If you confine your analysis to this best guess case, you ignore a set of futures with a 99.5 percent probability of occurring. Because uncertainties can have a significant impact on the results, you must design the analysis to reflect all major uncertainties. This usually means computing results for several contingencies. The number of cases to analyze and compute increases with each additional factor. Therefore the problem is to design the analysis to reflect only the most significant contingencies. You can use several techniques when dealing with uncertainty. Several of these techniques are:

Computer Simulation is one technique designed to help you in making decisions under uncertainty. If you can assign probability distributions to each major cost determinant, you can construct a computer program to simulate what is likely to occur. In effect, the computer randomly selects one value from each relevant distribution, combines it with other values from other distributions, and produces an estimated value for the investment. The computer repeats this process for various trials. When finished with the runs, the computer can plot the relative frequency of the various values. While simulation can be very useful, the technique does require obtaining probability distributions for the variables and involves a fair amount of programming and machine time costs. Thus, full scale simulation is generally feasible for projects with extensive funding.

Sensitivity Analysis is a somewhat less expensive simulation technique. It is an available alternative method of analyzing the outcomes of various projects or strategies. Instead of using probability distributions for each variable in the problem, you simulate the results by starting with the best guess estimate for each variable, then changing the values of the variables, within reasonable limits, to see the effects of the changes. This technique, known as sensitivity analysis,

is considerably less expensive than the full scale simulation and provides data for decision making purposes.

Contingency Analysis is a form of sensitivity analysis and involves evaluating the effect of new factors or conditions. You assess these new aspects by asking yourself questions of the type "what happens if . . . ?" For example, a comparison of two computer systems results in an established preference. You might ask, "What happens if a company develops a new computer family in five years?" Or you might ask, "What happens if the company closes my department? Can I adapt the system to another operation?" The chance of an event occurring may be subjective or have assigned probability.

A Fortiori Analysis is a method you use to overcome your preconceived bias when comparing alternatives A not uncommon situation involves replacement of a current, satisfactory production machine with new equipment. You may hesitate to make the change because of the unknown performance of the new machine. Considering this uncertainty and the satisfactory performance of the old machine, you may want to dismiss the change with only perfunctory consideration. This could preclude superior performance. A Fortiori analysis is also perfunctory, resulting not in firm recommendations, but only in indications. Its use is dependent upon your realization of your inner bias. With this realization, you set the numerical values of any unknown to favor the less desired alternative. That is, you counteract your bias for one alternative by favoring the other. For example, you would set minimum values for operating cost and maintenance downtime and a maximum value for production output of the new equipment. If the eventual comparison of alternatives is favorable for the "old machine," the analysis assures you that your inner bias did not force the decision. Yet, if the comparison favors the new machine, you need to perform more evaluations to find more realistic values of the variables.

CHAPTER 17

SENSITIVITY ANALYSIS

INTRODUCTION

Sensitivity is the relative magnitude of change in elements of an economic analysis that will cause a change in the ranking of alternatives. In a sensitivity analysis, if you vary one factor over a wide range without affecting the ranking of alternatives, you say that the analysis is insensitive. That means that the analysis isn't vulnerable to uncertainty surrounding that factor.

Contingency analysis is a special form of sensitivity analysis. It considers the potential impact of changes on the alternatives. Contingency analysis answers "what if" questions. For example, what if the economic life were 5 years instead of 8?

Sensitivity and contingency analysis do not require sophisticated techniques. Instead, they compel you to recognize and handle uncertainties in an economic analysis.

STEPS IN PERFORMING A SENSITIVITY ANALYSIS

First, you must decide if you need a sensitivity analysis at all. If one option is clearly superior to the rest, you do not need to test for sensitivity. When the choice is not clear amidst the uncertainty of future conditions, you must do a sensitivity analysis.

Sensitivity analysis should test the dominant input variables. That is, those having a major impact on the total present value costs or the benefits for a given alternative. Identification of the major cost contributors does not mean that you found the truly critical items. The choice of input variables may depend upon the degree of confidence that you placed in these estimates. Some elements you scrutinize and evaluate are:

1. Cost Estimates. Increasing or decreasing major cost elements, that is, those significantly impacting upon the present value cost. Such cost may be the cost of renting equipment, the price you pay for labor, or the amount of supplies you consume as part of your operations.

2. Length of System Life. Shorter or longer system life.

3. Volume, Mix, or Pattern of Workload. Variation in the estimated volume, mix or pattern of work load.

4. Requirements. Changes in requirements resulting from either legislative mandate or changes in functional or organizational structure.

5. Configuration of Equipment or Software. Changes in the hardware, software, data communications and other facilities.

6. Assumptions. Alternative assumptions concerning requirements, operations, facilities, or software, among others.

The basic procedure for sensitivity testing is simple. Select a factor to test. Hold all parameters in the analysis constant except that factor. Rework the analysis using different estimates for the factor under consideration. Check the results. If the changes affect the ranking of alternatives, then the analysis is sensitive to that variable.

You should test each key parameter individually to find its effect on the analysis.

Example 17-1

1. Given the following cost data, find the less costly alternative:

Cost and Year Incurred	Alternative A Proposed	Alternative B (Status Quo)
Year One		
ADPE	$ 80	0
System Development	100	0
Site Preparation	35	0
Years Two - Nine		
Personnel	$ 80/year	$120/year
Other Operating Costs	20/year	25/year

2. What if the system development costs are $130?

3. What if the system development costs are $120?

4. What if personnel costs increase to $85 per year?

Solution

1. The net present values for Alternatives A and B are:

$$PV_A = .954\ (\$80 + \$100 + \$35) + 5.088\ (\$80 + \$20)$$
$$= \$205 + \$509 = \underline{\$714}$$

$$PV_B = 5.088(\$120 + \$25) = \underline{\$738}$$

Alternative A, the proposed system, is less costly.

2. If system development costs are $130:

$$PV_A = .954(\$80 + \$130 + \$35) + 5.088(\$80 + \$20)$$
$$= \$234 + \$509 \qquad = \underline{\$743}$$

$$PV_B = 5.088(\$120 + \$25) = \underline{\$738}$$

Now, B costs less. You change the ranking and note the analysis is sensitive to a $30 increase in development costs.

3. If system development costs are $120:

$$PV_A = .954(\$80 + \$120 + \$35) + 5.088(\$80 + \$20)$$
$$= \$224 + \$509 \qquad = \underline{\$733}$$

$$PV_B = 5.088(\$120 + \$25) = \underline{\$738}$$

Alternative A remains less costly than B. Maintain the rankings and note the analysis is insensitive to a $20 increase in system development costs.

4. If annual personnel costs increase to $85, then:

$$PV_A = .954\ (\$80 + \$100 + \$35) + 5.088(\$85 + \$20)$$
$$= \$205 + \$534 \qquad = \underline{\$739}$$

$$PV_B = 5.088(\$120 + \$25) = \underline{\$738}$$

Now, A costs more than B. Change the ranking and note the analysis is sensitive to a $5 increase in annual personnel costs.

Example 17-2

Suppose the economic life in example 17-1 is questionable. What if the economic life is *5* years instead of *8*?

Solution

Based on an 8-year economic life, the present values of Alternatives A and B are:

$$PV_A = .954\ (\$80 + \$100 + \$35) + \underline{5.088}\ (\$80 + \$20)$$

$$= \$205 + \$509 = \underline{\$714}$$

$$PV_B = 5.088(\$120 + \$25) = \underline{\$738}$$

Alternative A, the proposed system, is less costly.

Based on a 5-year economic life, the present values of Alternatives A and B are:

$$PV_A = .954\ (\$80 + \$100 + \$35) + \underline{3.616}(\$100)$$

$$= \$205 + 362 = \underline{\$567}$$

$$PV_B = 3.616(\$120 + \$25) = \underline{\$524}$$

As $567 is more than the costs of the existing system, you change your ranking. Thus, the analysis is sensitive to a shorter economic life.

SENSITIVITY AND BREAK-EVEN ANALYSIS

Break-even analysis is useful for determining the point at which a particular factor becomes sensitive. In Example 17-1, you can find a break-even point for each parameter by setting the cost equations for the two alternatives equal to each other and solving for the unknown variable. In each case this variable is the factor you tested for sensitivity.

The break-even points are:

1. System development break-even cost:

$$\begin{aligned} .954\ (\$80 + x + \$35) + 5.088(\$100) &= 5.088(\$120 + \$25) \\ .954x + \$110 + \$509 &= \$738 \\ .954x &= \$119 \\ x &= \underline{\$125} \end{aligned}$$

If system development costs are $125 and you hold all other costs at their original estimates, the alternatives will have equal present values. If system development *costs are less than $125, you recommend the proposed alternative.* If system development *costs exceed $125, you recommend the status quo.*

2. Personnel break-even cost:

$$\begin{aligned} .954(\$215) + 5.088(x + 20) &= 5.088(\$145) \\ \$205 + 5.088x + \$102 &= \$738 \\ 5.088x &= \$431 \\ x &= \underline{\$84.7} \end{aligned}$$

If personnel costs are $85 and you hold all other costs at their original estimates, the alternatives will have equal present values. If personnel costs are less than $85, you recommend the alternative. If personnel costs are greater than $85, you recommend the current system.

PRESENTING THE RESULTS

You can use tables, charts and graphs to highlight the results of the sensitivity analysis. Graphs are particularly useful because they provide a visual interpretation of the results over a continuous range of possibilities.

Figure 17-1 shows the sensitivity of the system development costs. The vertical axis represents the PV cost and the horizontal axis represents the system development cost. The intersecting lines represent PV costs for each alternative. The *status quo remains constant at $738. Points A, B and C* represent the present values for the proposed alternative when the system development costs are $100, $120, and $130. The point at which the two alternatives intercept is the break-even point. To the left of the break-even point the proposed system is cheaper and to the right the status quo is cheaper.

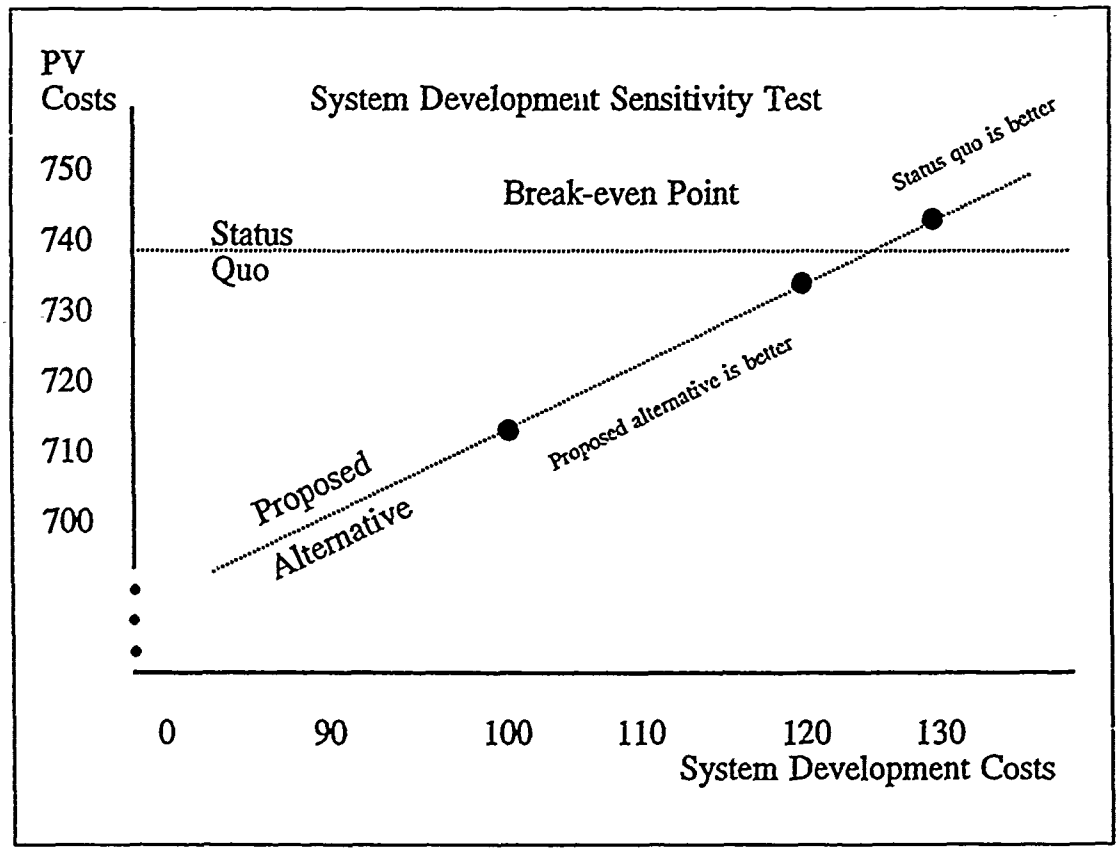


Figure 17-1

Similarly, Figure 17-2 plots the sensitivity of the annual personnel costs, where points A and B represent the present values when personnel costs are $80 and $85.

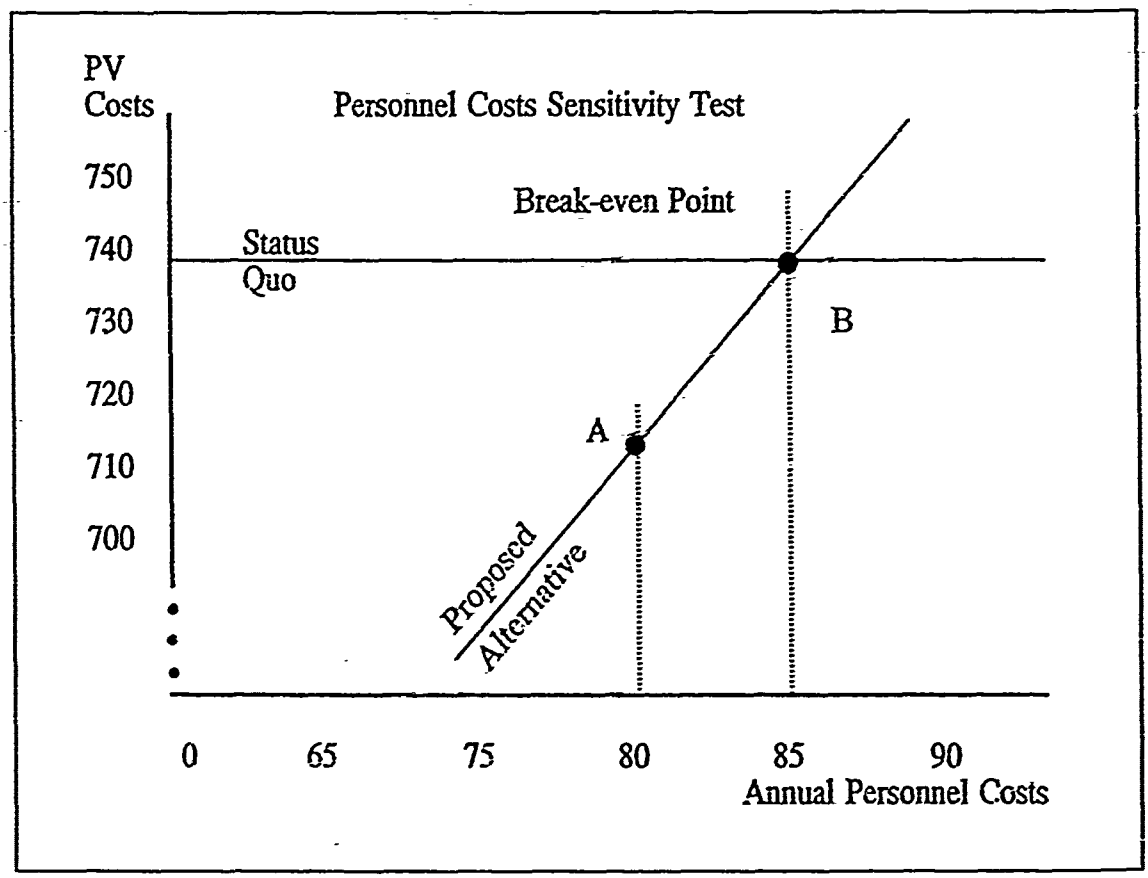


Figure 17-2

TWO VARIABLE SENSITIVITY TESTS

Often, the outcome of an economic analysis is sensitive several factors. You may extend the graphical techniques of the previous section to treat two variables simultaneously. For example, you can depict the PV life cycle cost of the proposed alternative in Example 17-1 for simultaneous variations in annual personnel costs and system development costs. If the *system development cost is D* and the *annual personnel cost is P*, total PV life cycle cost is:

$$PV = .954(80 + D + 35) + 5.088(P + 20)$$

Figure 17-3 plots total PV life cycle costs for various system development and personnel costs. The horizontal axis depicts personnel cost, P. Development cost, D, is an exogenous variable, its origin found external to this problem. The lattice of PV life cycle cost points show which blend of system development and personnel costs are preferable to the status quo. The circled point represents the "best guess." The original analysis used D = $100 and P = $80.

Inspection of the graph reveals if the proposed alternative is economically sound. It is sound if, and only if, the PV point for the proposed alternative lies below the status quo threshold. The graph also allows you to interpolate visually between designated development and personnel costs. For example, if the actual system development costs were $110 and the annual personnel costs were $77 the PV would be approximately $708 (see point Y in Figure 17-3).

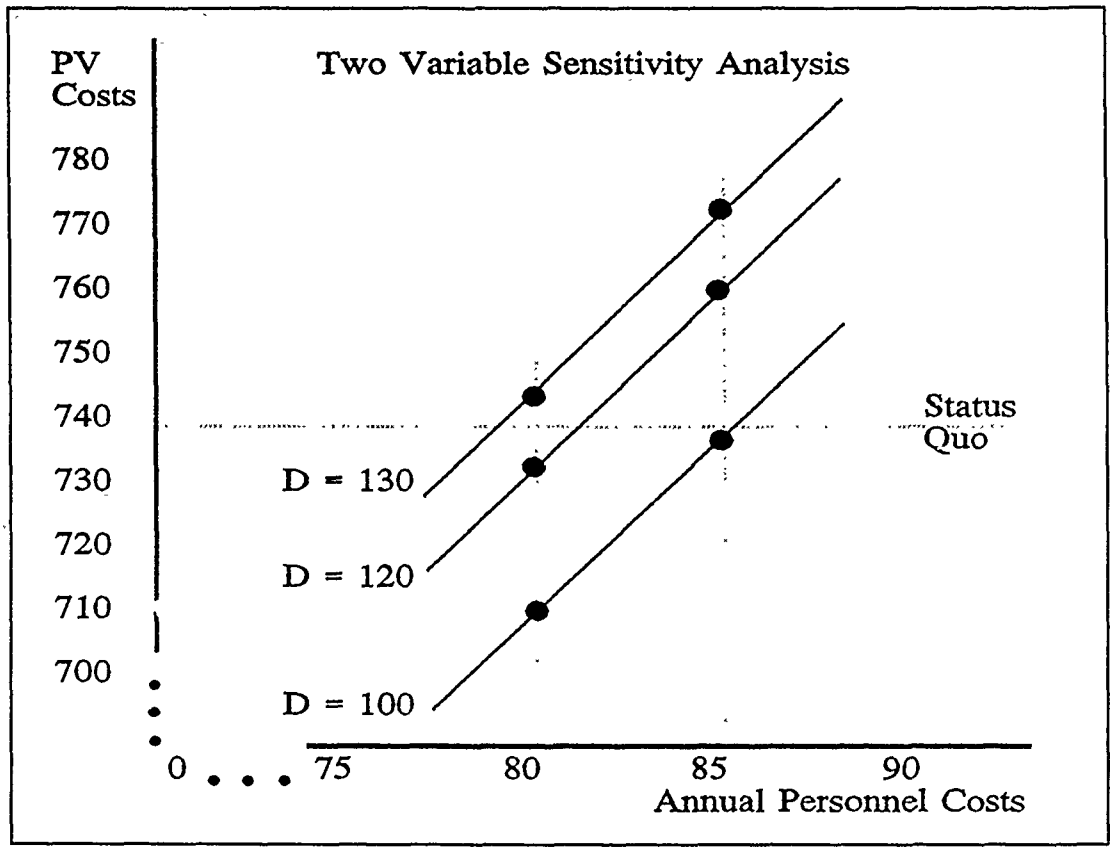


Figure 17-3

APPENDICES

APPENDIX A

WRITING THE ECONOMIC ANALYSIS REPORT

WRITING THE REPORT

The economic analysis report is the major tangible product of your study. Your seniors use this to decide whether to carry out your recommendations or not. You must ensure that it is a high quality product. You must write and present your report with the same care you used in the other phases of your economic analysis.

You may present your findings and recommendations to several levels of management within your organization. So, you write your report with varying amounts of detail in its various parts, as described below.

Executive Summary. This is a concise summary of your economic analysis. You place this at the beginning of your report to tell upper management of the coverage of your study, major costs and benefits you noted, and your recommendations. This part of your report is particularly important owing to the time constraints of management. Therefore, your summary must be succinct and present the salient findings of your work.

Main Body of the Report. Here, you discuss all relevant findings, recommendations, benefits and special observations or considerations. If applicable, you suggest steps for implementation.

Appendices. You use appendices after your report to present lengthy, detailed data to support your findings and recommendations.

VISUAL AIDS FOR PRESENTING DATA

Use visual aids to show data. Visual presentations such as charts, graphs and figures improve your report's readability. Visual aids help others comprehend the impact of the ratios and relationships you present. Charts, graphs and figures should be clear, brief, and specifically relate to your text.

SUGGESTED OUTLINE FOR YOUR REPORT

No set format exists for preparing the economic analysis report. A suggested outline is:

I. INTRODUCTION

A. Background. Provide a general overview of the existing environment. Identify the specific problem or opportunity you studied and provide a history of major events leading to the problem.

B. Scope. Identify the scope of your study.

C. Methodology. Summarize your procedures for conducting the analysis and the techniques you used in estimating and computing costs and benefits. Provide details in an appendix.

II. OBJECTIVE

State the major objectives of the program or project you studied. State objectives in terms of a functional need without implying how you will do them.

III. ASSUMPTIONS

State all the assumptions you used in your economic analysis. Include the expected economic life and the period of comparisons and all constraints, limitations, or exclusions related to your analysis.

IV. ALTERNATIVES

Describe the technical and operational characteristics of the alternatives considered, including the current system.

A. Current System. The current system identifies the level of costs and benefits that would accrue if you did not change your present method of operation. A current system serves as a baseline you use to compare new possibilities.

B. Proposed System. Describe the idea for each proposed alternatives. You address but need not quantify alternatives that you can show to be feasible.

V. COST ANALYSIS

Identify and describe cost elements for each alternative. Include the computations you used to devise total costs and describe in detail the method for developing cost estimates. Use tables, charts, graphs, mathematical models and other visual aids to help in presentation of costs.

VI. BENEFIT ANALYSIS

Identify and describe all benefits the implementation of each alternative would obtain. Quantify benefits whenever possible. Identify criteria you used for measuring benefits and include tour computations. Provide a general narrative description of intangible benefits. Do not include savings under benefits. They belong in your cost analysis section.

VII. COMPARISON OF ALTERNATIVES

Compare your alternatives using an appropriate economic analysis technique. Present results in a convenient fashion using charts, tables, graphs or other visual aids whenever possible. NOTE: Whenever the period of comparison is greater than three years, you must compare the alternatives in terms of discounted costs and benefits.

VIII. SENSITIVITY ANALYSIS

Describe the approach and assumptions you used for conducting you sensitivity analysis. Identify and display the results of your analysis for all alternatives for each factor tested. Use tables, graphs and charts to present data and include a narrative to highlight key points in your evaluation.

IX. CONCLUSIONS

Present your conclusion in a clear, concise manner. Your conclusion is a be brief statements of the most important findings you present in your report. Do not introduce new material in your conclusion. Do not include justifying sentences in your conclusion. The body of your report should have done that already. Make your point and stop.

Once you arrive at your conclusion, be sure that your discussion substantiates it.

X. RECOMMENDATIONS

Your recommendations follow from your conclusions. Draft your recommended actions in brief, clear, positive statements. Your recommendation must meet the test of suitability, feasibility, and acceptability if they are to provide a complete and workable solution to the problem.

APPENDIX B

ECONOMIC ANALYSIS REVIEW CHECK LIST

THE OBJECTIVE

1. Did you clearly state your objective? Does it define the purpose of the program, project or activity under study?
2. Can you realistically obtain the objective?
3. Did you state the objective in terms of output or accomplishment?
4. Did you define the output or accomplishments in quantifiable, measurable terms?
5. Did you specify the criteria for selection of a preferred course of action?
6. Can you measure the progress toward attainment of the objective?
7. Did you phrase the objective statement so that it does not unnecessarily limit the type and variety of potential alternatives?
8. If you require a completion or implementation date, did you specify the date?

THE ASSUMPTIONS AND CONSTRAINTS

1. Did you identify and explain all reasonable assumptions?
2. Are your assumptions too restrictive? Too broad?
3. Are your assumptions realistic and justified?
4. Does each assumption have an identified basis?
5. Do you use assumptions only when you could not obtain facts?
6. Do your assumptions preclude other alternative solutions?
7. Do your assumptions include economic life and future workload?
8. Did you establish a project period?
9. Did you consider funding and budget constraints?

10. Did you include space and construction requirements?

11. Did you include necessary geographical constraints?

THE ALTERNATIVES

1. Are your alternatives feasible? Can they meet the stated objectives?

2. Are your alternatives well defined and discreet? Do they overlap?

3. Is the total number of alternatives sufficient? Have you omitted any feasible alternatives?

4. If adequate, did you use the status quo as a base for comparison?

5. If appropriate, did you evaluate lease versus buy?

6. Did you consider all feasible alternatives?

7. Did you identify alternatives you did not analyze with reasons for their omission?

8. If other government organizations can provide the desired product or service, did you include them as alternatives?

THE COST ESTIMATE

1. Did you include all relevant costs?

2. Do implementation costs include shipping, installation, support and training requirements?

3. Do labor costs consider specific skill levels, fringe benefits, overtime and shift differentials?

4. Did you include future equipment replacement as an investment cost?

5. Did you consider current asset values of reutilized equipment? Is the method of determining these values adequate?

6. Are your cost factors current and supportable?

7. Did you show why you consider certain costs relevant and others not?

8. Did you properly identify cost estimates and is their quality proper for the status of the program?

9. Did you identify estimating relationships and methodologies and are they adequate?

10. Did you exclude sunk costs?

11. Did you consider opportunity costs?

12. Did you associate terminal value with any of the alternatives?

13. Did you evaluate future costs in terms of constant dollars?

14. If you include inflation or cost escalation, did you identify the rate and the source of the rate?

15. Did you figure out cost savings or avoidance only by comparison with the status quo?

16. Are the costs of any alternative part of the analysis of only that alternative and not also as a cost savings in the evaluation of another alternative?

17. Did you discount cash flows using the 10% discount rate?

THE BENEFITS

1. Did you find relevant benefits? Does the analysis ignore any portion of total output?

2. Do the benefits relate to the project objective?

3. Did you identify the benefits in quantifiable, measurable terms, as much as possible?

4. Does the context of your analysis justify the criteria you used to measure benefits?

5. Did you define your estimating techniques?

6. Did you identify your sources of information and estimates?

7. Did you use an expert opinion? Did these experts have proper credentials?

8. Did you identify and use logical, convincing quantitative assessments instead of quantitative measures of benefits?

9. Did you go too far in attempting to quantify what you could not quantify? ***the

10. Did you identify and quantify negative aspects?

11. Did you exclude cost reductions (savings) from the benefit list to avoid double counting?

12. Did you develop a ranking or priority system for evaluating the importance of the benefits?

13. Did you tabulate all benefit information for ease of examination?

COMPARISON OF ALTERNATIVES

1. Did you compare alternatives using the proper techniques such as present value, benefit/cost ratios or break-even analysis?

2. Did you compare alternatives in relation to a common basis?

3. Does the analysis seem free of bias favoring one alternative? Was their comparison fair?

4. Did you use the same criteria, costing methods and time span for all the alternatives?

5. Did you combine cost and benefit information for each alternative to show relationships?

6. Did you adequately document the methods and sources of comparison?

SENSITIVITY ANALYSIS

1. Has the analysis important underlying uncertainties?

2. Is there important technological uncertainty?

3. Did you use ranges of values used for unknown quantities?

4. Did you show the effects of future states of nature?

5. Did you use break-even analysis to help evaluation of future uncertainties?

6. Would you keep your recommendation if unknown characteristics varied within a feasible range?

7. Did you illustrate the impact of the length of time for formal project approval?

8. Is the analysis too optimistic in its assumptions?

9. Is there a sensitivity analysis to show the effect of uncertainty in major cost estimates?

CONCLUSIONS AND RECOMMENDATIONS

1. Are the results of the analysis conclusive? Can you establish a concrete ranking of alternatives?

2. Did you recommend a specific course of action?

3. Did you logically derive your conclusions and recommendations from the material?

4. Did you emphasize all significant differences between the recommended alternative and others?

5. Are the recommendations feasible considering politics, culture, and policy?

6. Did you base the recommendations upon significant differences between the alternatives?

7. Are recommendations intuitively satisfying and unsupportable?

APPENDIX C
TABLE C-1

PROJECT YEAR DISCOUNT FACTORS

Year	Table A PRESENT VALUE OF $1 (Single Amount used when cash flows accrue in *varying* amounts each year).	Table B PRESENT VALUE OF $1 (Cumulative Uniform Series to be used when cash flows accrue in the *same* amount each year).
1	0.954	0.954
2	0.867	1.821
3	0.788	2.609
4	0.717	3.326
5	0.652	3.977
6	0.592	4.570
7	0.538	5.108
8	0.489	5.597
9	0.445	6.042
10	0.405	6.447
11	0.368	6.815
12	0.334	7.149
13	0.304	7.453
14	0.276	7.729
15	0.251	7.980
16	0.228	8.209
17	0.208	8.416
18	0.189	8.605
19	0.172	8.777
20	0.156	8.933
21	0.142	9.074
22	0.129	9.203
23	0.117	9.320
24	0.107	9.427
25	0.097	9.524
26	0.088	9.612
27	0.080	9.692
28	0.073	9.765
29	0.066	9.831
30	0.060	9.891

NOTE: Table B factors represent the cumulative sum of Table A factors through any given project year.

APPENDIX D

GLOSSARY OF TERMS

Alternatives - The different courses of action, means, or methods by which you may obtain objectives.

Assets - Property, both real and personal, and other items having monetary value.

Assumptions - Explicit statements used to describe the present and future environment upon which you base the economic analysis. Yo make assumptions to support and limit the scope of the study.

Baseline Date - The start for the economic analysis, beyond this date, decisions deal with future courses of action. It is the "today" in the analysis. You may call this the baseline year (or analysis year 0).

Benefits - Outputs or effectiveness you expect to receive or make over time because of making a proposed investment.

Benefit/Cost Ratio (BCR) - An economic indicator of efficiency, computed by dividing benefits by costs. When you quantify benefits in dollar terms, it is customary to discount both the benefit stream and the cost stream to reflect the present value of future costs and benefits.

Break-Even Analysis - A procedure for evaluating alternatives in terms of a common unknown variable. It involves solving for the value of the variable that will make the cumulative discounted costs for the alternatives equivalent; this value is the break even point.

Budget Estimate - Cost estimate prepared for inclusion in the DOD budget to support a system acquisition program.

Cash Flow Diagrams - A pictorial representation showing the magnitudes and timing of costs associated with an alternative.

Compound Interest - Interest you charge on both the original principal and its accrued interest.

Constant Dollars - Computed values that remove the effect of price changes over time. An estimate is in constant dollars if you adjust costs for all work so that they reflect the level of prices of a base year.

Contingency Analysis - A form of sensitivity analysis used to evaluate the effect of new factors

Cost - The value of things used up or expended in producing a good or service. Usually, you state costs in dollar terms. In economic analyses a cost value need not coincide with the budget estimate.

Cost Avoidance - Savings realized by obviating a planned nonrecurring expenditure of resources. A cost avoidance can only occur when adopting an alternative other than the status quo.

Cost Benefit Analysis - A technique for assessing the range of costs and benefits associated with a given option, usually to find feasibility. Costs are generally in monetary terms, but benefits need not be in monetary terms.

Cost Estimate - Cost projection for expected transaction based upon information available.

Current Dollars - Level of costs in the year actual cost will be incurred. When you state prior costs in current dollars, the figures are the actual amounts paid. When you state future costs in current dollars, the figures are the actual amounts you expect pay, including any amount due to future price changes.

Current Market Value - The amount for which an item could be sold in today's market. This can be the "going price" for a particular piece of used hardware in the open market or the trade-in allowance guaranteed by a particular manufacturer. Demand is greatest for computers that were at once the most popular models--because there is a larger more receptive market. Obscure machines, on the other hand, have lower prices, though they are as good or better than the popular models.

Delphi Method - Technique for applying the informed judgement of a group of experts, using a carefully planned program of sequential individual interrogations, without direct confrontation; and with maximum use of feedback of digested information in the investigation and solution of problems. Usually, this has a series of repeated interrogations using questionnaires. After the initial interrogation of each individual, you use the answers from the preceding round of replies to supplement subsequent questioning. You encourage the expert to reconsider, change, or defend his previous answer considering the answers of the other members of the group.

Discount Factor - The multiplier for any specific discount rate that translates expected cost or benefit in any specific future year into its present value. Mathematically the discount factor is $1 / (1 + r)^n$ where r is the discount rate and n is the number of years since the date of the initiation of a program or project.

Discount Rate - A rate used to relate present and future dollars. You express this rate as a percentage and use it to reduce the value of future dollars in relation to present dollars to account for the time value of money.

Discounted Payback - A technique for determining the period over which accumulated present value savings are sufficient to offset the total present value investment costs of a proposed alternative to the status quo.

Discounting - A computational technique using interest rate to calculate present value of future benefits and costs. Used in evaluating alternative investment proposals that can be valued in money.

Economic Analysis - A systematic approach to quantifying, portraying, and evaluating the relative worth of proposed projects. Economic analysis has six steps: stating tile objective; listing assumptions; defining the alternatives; determining costs and benefits; comparing and ranking alternatives; and performing a sensitivity analysis.

Economic Forecasting - Predicting the future movement of economic indicators, such as GNP and indices.

Economic Life - The period over which you expect to accrue the benefits from a proposal. The economic life of a project begins the year the investment starts producing benefits and may be limited by its mission life, physical life, or technological life.

Effectiveness - The rate at which you progress toward the goal or objective of a program. Rate at which a program makes benefits.

Efficiency - The degree of optimization a program gives to its outputs. This pertains to both the productivity and the input mix.

Fixed Cost - That component of production cost that does not change if volume is within a specified range.

Fortiori Analysis - A technique used to overcome preconceived bias. You set the numerical values of unknowns to favor the less desired alternative. If the eventual comparison of alternatives still favors the "preferred" alternative, this assures you that your inner bias did not force the decision.

Fringe Benefits - Allowances and services provided to employees as compensation besides basic salaries and wages.

Historical Cost - The cost of any objective, based upon actual asset outlay, determined after the fact. Any method of cost determination may be used.

Imputed Cost - A cost that does not appear in accounting records and does not entail dollar outlays.

Incremental Cost - The additional resources needed to get some specific additional capability. Any cost you would incur despite which alternative you adopt is not an incremental cost. You need not include it in an analysis.

Industrial Engineering Method - Cost estimating technique where you consolidate estimates for various separate work segments into a total project estimate.

Inflation - A persistent rise in the general level of prices over time.

Intangible Benefits - Those improvements in system performance that cannot be quantified in terms of dollars or other measurer.

Interest - A price (or rent) charged to use money.

Investment Cost - One-time costs associated with acquisition of real property, nonrecurring services, nonrecurring operations, and maintenance (start-up) costs and other onetime costs. Despite their one-time nature, investment costs may extend over periods of more than one year.

Lead Time - The period of elapsed time between initial funding or decision and the commencement of the economic life.

Life-cycle - The time from the beginning date of the project to the end of the program or project life.

Life-cycle Cost - The total cost to the Government of buying and owning a system over its full life. It includes the cost of development, acquisition, operation, support, and where applicable, disposal.

Mission Life - The period over which you anticipate a need for an asset,

Net Discounted Cost - Discounted dollar cost minus discounted dollar benefits. (This can be a negative value.)

Nonrecurring Cost - Costs that occur once; to be set apart from annually recurring cost.

Objectives - Goals or results that the decision maker wants to attain. It is the desired product or output of a program. The objectives justify the existence of the organization and its consumption of resources. You must state objectives in a way that does not preclude alternative approaches.

Opportunity Cost - The cost of forgone opportunities; the sacrificed amount of money, equipment, or units of production you could have used for another alternative with the same time and effort expended.

Output - The products, functions, tasks, services, or capabilities that an organization exists to produce, do, or maintain.

Output Measures - A useful description of functions, or missions of an organization, expressed in relation to those assigned.

Parametric Cost Estimate - Estimate derived from statistical correlation of historic system costs with performance and physical attributes of the system.

Physical Life - The period when a machine, piece of equipment, or building physically can do its function.

Present Value - The estimated current worth of future benefits or costs derived by discounting the future values, using an appropriate discount rate.

Price Index - A percentage comparison of the total costs of a selection of commodities and services between two periods.

Program/Project - A major mission oriented, agency endeavor, that fulfills statutory or executive requirements. You define this in terms of the principal actions required to get a significant end objective.

Program Evaluation - An analysis of ongoing activities to find out how to improve an approved program/project based on actual performance. Program evaluation studies entail a comparison of actual performance with the approved program/project goals and objectives, and provide a basis for deciding whether the project meets its objectives in the most cost effective manner.

Project Life - The lead time and economic life.

Recurring Costs - Expenses for personnel, material consumed in use, operating, overhead, support services, and other items that recur annually in execution of a given program or work effort.

Residual Value - The computed value of an asset at any time.

Savings Investment Ratio (SIR) - The ratio of discounted future cost savings to the discounted investment cost necessary to effect those savings. An SIR of one tells that the present value of the savings equals the present value of the investment.

Sensitivity Analysis - A technique for assessing the extent to which reasonable changes in assumptions or input variables will affect preference ranking of alternatives.

Simulation - Artificial generation of experimental processes to initiate or duplicate actual operational processes.

Sunk Cost - A resource that you use because of a prior decision. Because you irrevocably expend or commit to sunk costs, they do not affect your choice between alternatives.

Tangible Benefits - Those improvements in system performance that you cannot quantify. They do not include savings in recurring operating expenses; you reflect these savings as reductions in cost.

Technological Life - The estimated number of years before technology will make the existing or proposed equipment or facilities obsolete.

Terminal Value - The proceeds (less removal and disposal costs) you get when disposing of a tangible capital asset. Usually, you measure this by the net proceeds from the sale or other disposition of the asset, or its fair market value if you trade the asset for another asset.

Time Value of Money - A name given to the idea that the use of money costs money. A dollar today is worth more than a dollar tomorrow because of the interest costs related to expenditures and benefits that occur over time. Annual savings or cash inflows projected for tomorrow have present values less than their undiscounted dollar values.

Uniform Annual Cost (UAC) - A constant amount that, if paid annually throughout the economic life of a proposed alternative, would yield a total discounted cost equal to the actual present value life cycle cost of the alternative.

Variable Cost - A cost that varies with the quantity of output produced.

APPENDIX E

ECONOMIC ANALYSIS EXAMPLE:

ECONOMIC ANALYSIS OF THE REPLACEMENT OF ADPE

I. INTRODUCTION

A. Background. At our installation, the user's demand for information services has saturated our computer. To do our current workload, we operate our computer around-the-clock, at full capacity. In addition, we do our workload using commercial timesharing services. We expect our workload to continue to grow each year. Since our work has saturated the in-house computer, we use timesharing to handle the growing workload. Due to the high timesharing costs, our Commander directed that we investigate the feasibility of replacing our current hardware with a larger, more efficient machine. Replacement of the current equipment would allow the activity to bring all timesharing workload in house. In addition it would allow the activity to complete its workload operating two shifts per day instead of three, thus reducing personnel costs by ⅓.

B. Scope. In keeping with GSA policy, the analysis examined the r placement of current equipment under a competitive procurement. Thus, we did not consider the alternative to augment current equipment with compatible equipment via a sole source procurement.

C. Methodology. For this analysis, we compared the costs and benefits of the proposed ADPE procurement with the current system. We did this by first examining the current and projected ADP workload at our activity. Once we set the workload, we figured out the ADPE requirements for a new Brand Z computer and the future timesharing requirements under the current system. We found costs and benefits for both alternatives. We compared the alternatives in terms of their present value costs over a nine year period. We did a sensitivity analysis to decide what degree of changes in certain cost factors would affect the results of the analysis.

II. OBJECTIVE

The objective of this analysis is to examine the economic feasibility of replacing the existing ADP system with new equipment.

III. ASSUMPTIONS

A. The new system must be large enough to support the current in-house and timesharing work load and projected workload growth throughout the life cycle.

B. The economic life of the system is seven years from the point of full implementation.

C. Only major vendors can absorb the cost of running the bench mark, therefore, only major vendors will bid.

D. The two compatible vendors will continue their practice of non-competitive bidding, thus the procurement will result in non-compatible equipment.

E. To transfer the in-house workload to the Brand Z computer will require six months. To transfer the timesharing workload will require three months.

G. All new applications developed after the installation of the new equipment will use the new equipment without conversion.

H. We will lease ADPE.

I. All costs and salaries reflect those in effect during the current fiscal year. We made no provision for inflation.

J. MILCON funding will be available for construction of additional space.

K. Figure E-1 shows major milestones for the proposed alternatives.

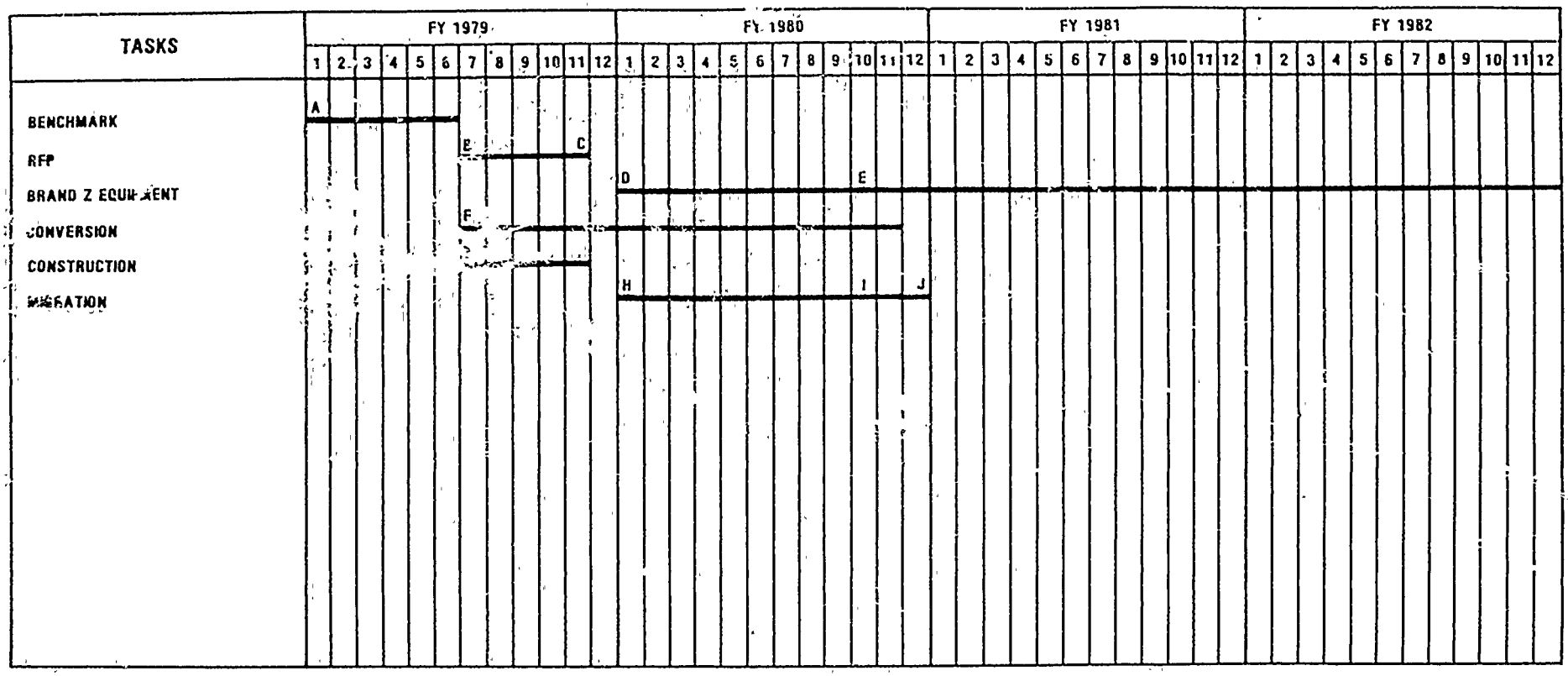
IV. ALTERNATIVES

A. Current System. We will continue to operate the computer center as we do today. Because the computer center already operates three shifts per day at full capacity, we will require no additional staffing nor in-house operating costs in the out years. We will support all new workload through commercial timesharing.

B. Brand Z System. We will replace the existing ADP equipment through a traditional competitive procurement. Contractors, with the help of in-house personnel, will make a bench mark package. We will require the vendors to run the bench mark at their expense. We will award the contract to the best vendor. We will do a massive conversion effort to make all existing programs compatible with the new equipment. The migration of in-house workload will occur three months after contract award and take eight months to complete. The migration of the timesharing workload will occur one year after contract award and take two months to complete. Then, we will release the current system. Once the Brand Z system is fully operational, we will reduce operations from three to two shifts per day. At this time, we will transfer nearly ⅓ of the personnel.

Figure E-1

MAJOR MILESTONES



A BEGIN BENCHMARK CONSTRUCTION

B ISSUE RFP

C AWARD BRAND Z CONTRACT

D INSTALL BRAND Z EQUIPMENT

E RELEASE CURRENT EQUIPMENT

F BEGIN CONVERSION

G BEGIN CONSTRUCTION

H BEGIN MIGRATION OF INHOUSE WORKLOAD

I BEGIN MIGRATION OF TIMESHARING WORKLOAD

J SYSTEM IS FULLY OPERATIONAL

V. COST ANALYSIS

We estimate nonrecurring and recurring costs for each alternative. Nonrecurring costs are those costs made once, only!. Recurring costs are those costs incurred repeatedly, throughout the project life. Tables E-1 through E-3 shows the nonrecurring and recurring costs. Cost elements are:

A. Nonrecurring Costs

1. Bench Mark Construction. We will contract-out the bench mark package for an estimated cost of $35,000. A six person bench mark team will help the contractors to prepare the bench mark package. The cost of the bench mark team includes salaries, travel, per diem and miscellaneous expenses for a six-week period. Based on a GS-13 step five, the salary and fringe benefits will cost $4523 per person. We estimate travel costs for three trips at a transportation cost of $1000 per person and per diem for 42 days at $75 per day. Other expenses include rental cars for six weeks at $300 per car per week. The total cost for the bench mark team is $55,638.

2. Conversion. We used NAVDAC's Project Management Control System (PMCS) to project our conversion costs. We will contract out the conversion at a cost of $45,000 per labor-year. The conversion effort will require 125 labor-years and will take place over a 17 month period. The total conversion cost is $5,625,000.

3. Construction. Alternative B requires additional floor space for the Brand Z equipment. Total construction cost is $1,263,200. This is for construction of 8,000 square feet at $129 per square foot to house the computers and support equipment and construction of 3400 square feet at $68 per square foot to house the Uninterruptable Power Supply (UPS) upgrade.

4. Initial Computer Room Equipment. We will install miscellaneous computer room support equipment (tape storage racks, tape cleaners, tables, console operator chairs, among others) to support the initial Brand Z equipment. This equipment will cost $30,000.

5. Upgrade of UPS System. Brand Z equipment draws more electricity than our current equipment and require an initial UPS upgrade of 550 KVA. In year four, this will require an additional upgrade of 650 KVA. The costs of the upgrades in years one and four are $610,100 and $725,500.

6. Migration of Workload. Migration is the transfer of the in-house and timesharing workload to the Brand Z equipment. We will migrate using in-house personnel paid overtime. Based on the MPCS, the effort will require 69,600 hours of overtime (49,700 hours for the in-house workload and 19,900 hours for the timesharing workload). We estimated the costs of the migration effort using the overtime rate for a GS-6 step five. The hourly overtime costs including fringe benefits and leave is $14.23 per hour. Thus, the migration costs for the in-house and timesharing workloads are $707,200 and $283,200.

TABLE E-1

NONRECURRING COSTS ($000)

ALTERNATIVE: B

COST CATEGORY	FY79	FY80	FY81	FY82	TOTAL
Benchmark Construction					
a. Benchmark Package	$335.0				$335.0
b. In-house Benchmark Team	46.9				46.9
Conversion	1985.3	$3639.7			5625.0
Construction	1263.2				1263.2
Computer Room Equipment		30.0			30.0
UPS Upgrade	610.1			$723.5	1333.6
Migration of Workload					
a In-house Workload		707.2			707.2
b. Timesharing Workload		283.2			283.2
Supplies		174.2			174.2
Utilities					
a. Computer power		110.6			110.6
b. General Utilities		47.4			47.4
Personnel Separation		105.2			105.2
Terminal Value of Owned Equipment		(1650.0)			(1650.0)
TOTALS	$4240.5	$3447.5		$723.5	$8411.5

TABLE E-2
RECURRING COSTS ($000)
ALTERNATIVE A

COST CATEGORY	FY79	FY80	FY81	FY82	FY83	FY84	FY85	FY86	FY87	TOTAL
ADP Timesharing	$ 420.9	$ 704.9	$1387.6	$1804.5	$2344.3	$3049.2	$3963.6	$5151.8	$6696.6	$25,523.4
ADPE Rental/Maintenance	4248.0	4248.0	4248.0	4248.0	4248.0	4248.0	4248.0	4248.0	4248.0	38,232.0
Utilities										
Computer Power	248.8	248.8	248.8	248.8	248.8	248.8	248.8	248.8	248.8	2232.0
General Utilities	106.6	106.6	106.6	106.6	106.6	106.6	106.6	106.6	106.6	959.4
Personnel	3616.8	3616.8	3616.8	3616.8	3616.8	3616.8	3616.8	3616.8	3616.8	32,551.2
Supplies	550.0	550.0	550.0	550.0	550.0	550.0	550.0	550.0	550.0	4950.0
TOTAL	$9191.1	$9475.1	$10,157.8	$10,574.7	$11,114.5	$11,819.4	$12,733.8	$13,922.0	$15,466.8	$104,455.2

TABLE E-3
RECURRING COSTS ($000)
ALTERNATIVE B

COST CATEGORY	FY79	FY80	FY81	FY82	FY83	FY84	FY85	FY86	FY87	TOTAL
ADP Timesharing	$ 420.9	$ 420.9								$ 841.8
ADPE Rental/Maintenance										
Current Equipment	4,248.0	3,186.0								7,434.0
Brand Z Equipment		4,825.0	$4,825.0	$4,825.0	$4,825.0	$4,825.0	$4,825.0	$4,825.0	$4,825.0	38,600.0
Utilities										
Computer Power	248.8	235.0	276.5	290.3	304.8	320.1	336.1	352.9	370.5	2,735.0
General Utilities	106.6	100.7	118.5	124.4	130.6	137.2	144.0	151.2	158.8	1,172.0
Personnel	3,616.8	3,315.4	2,411.2	2,531.8	2,658.3	2,791.3	2,930.8	3077.4	3,231.2	26,564.4
Supplies	550.0	550.0	577.5	606.4	636.7	668.5	702.0	737.1	773.9	5,802.1
TOTAL	$9,191.1	$12,613.0	$8,208.7	$8,377.9	$8,555.4	$8,742.1	$8,937.9	$9,143.6	$9359.4	$83,149.1

7. Supplies. We estimate that the migration will use $174,200 of supplies.

8. Utilities. The migration effort will use approximately 400 KVA of electricity. Based on a NAVFAC estimating formula, the computer power cost is $110,600 (400 KVA x .8 usage factor x $.04 cost factor x 720 hours per month x 12 months). Experience shows that the computer power requirement represents 70% of the total utilities cost, while general utilities including air conditioning, lighting, and others, comprise the remaining 30%. Based on this information, the general utilities cost is $47,400.

9. Personnel Separation Costs. The elimination of the third shift will reduce personnel requirements by ⅓ (eight military, 64 civilians). We will reduce the military billets through normal attrition. Since we routinely transfer military personnel to new duty stations when they finish their tour, we incur no additional separation costs.

We will give priority rights to civilian employees whose jobs we eliminate, to move them to other vacant positions in DOD and other Federal agencies. Based on DOD experience, approximately 75% of the displaced workers will find other jobs or retire. We will force separate the other 25%. The estimated cost to separate an employee is $6575. Thus, the estimated separation cost for 16 civilians is $105,200.

10. Terminal Values of Owned Equipment. The Government owns part of the current equipment. When Brand Z is fully operational, we can release this equipment for sale or reutilization by other government activities. The projected market value for the equipment at the time of its release is $1,650,000.

B. Recurring Costs

1. ADP Timesharing. Because our current workload has saturated our computer, we use commercial timesharing to do the excess work. The cost for the timesharing services is $2014 per CPU hour. Unless we get new equipment, we expect to use more timesharing each year to meet the ADP workload growth. Table E-4 shows projected timesharing workload and its costs.

TABLE E-4
PROJECTED TIMESHARING
WORKLOAD

Year	CPU Hours	Costs
1	209	$420,900
2	350	704,900
3	689	1,387,600
4	896	1,804,500
5	1164	2,344,300
6	1514	3,049,200
7	1968	3,963,600
8	2558	5,151,800
9	3325	6.696.600
		$25,523,400

2. ADPE Rental/Maintenance

a. Current Equipment. Annual rental/maintenance for the current ADPE is $4,248,000. Under Alternative A, we incur this cost throughout the project life. Under Alternative B, we will incur this cost until we release the equipment.

b. Brand Z Equipment. The annual rental/maintenance for Brand Z equipment is $4,825,000.

3. Utilities

a. Current Equipment. The current equipment uses 900 KVA to do the in-house workload. Based on the NAVFAC formula, the computer power cost is $248,800 (900 KVA x .8 usage factor x .04 cost factor x 720 hours per month x 12 month per year). The cost for general utilities is $106,600. Since our current workload saturates our equipment, we made no provisions for workload growth.

b. Brand Z Equipment. The Brand Z equipment needs 700 KVA to do the current in-house workload and 300 KVA to do the initial timesharing workload. Based on the NAVFAC formula, the utilities cost for the first year of full use is $276,500 for computer power and $118,500 for general utilities. After that, utilities costs will increase 5% each year due to workload growth.

4. Personnel. We based civilian personnel costs on current annual salaries and adjusted the pay rates and salaries per the Office of Management and Budget guidance to include a 26% fringe benefit factor. We based military personnel costs on the composite military pay rates identified in the NAVCOMPT manual. We adjusted these to include a 29% fringe benefit factor for officers and a 40% factor for enlisted personnel.

a. Alternative A. The computer activity currently runs three shifts per day, requiring 216 people. Table E-5 identifies personnel costs. The annual personnel costs are approximately $3,616,800 and will remain constant throughout the life cycle.

TABLE E-5
CURRENT PERSONNEL REQUIREMENTS

Grade	Number of People	Annual Salary	Salary + Fringe Benefits	Personnel Costs
E-5	12	$11,507	$16,100	$ 193,320
E-4	9	9,747	13,646	122,814
0-5	3	34,047	42,559	127,677
GS-7	24	14,750	18,585	446,040
GS-6	120	13,272	16,723	2,006,760
GS-5	48	11,907	15,003	720,144
Totals	216			$3,616,755

b. Alternative B. Alternative B will operate with current personnel until 1 July of the first year after implementation when the Brand Z equipment becomes fully operational for the in-house workload. Then, we will release the current equipment and run two shifts per day, reducing initial personnel requirements by ⅓. Personnel costs to support initial requirements are $2,411,200. Table E-6 shows these costs. After 1 July, we expect personnel costs to increase by five percent due to the growth in workload.

TABLE E-6
INITIAL PERSONNEL REQUIREMENTS FOR BRAND Z

Grade	Number of People	Annual Salary	Salary + Fringe Benefits	Personnel Costs
E-5	8	$11,507	$16,110	$ 128,880
E-4	6	9,747	13,646	81,876
0-5	2	34,047	42,559	85,118
GS-7	16	14,750	18,585	297,360
GS-6	80	13,272	16,723	1,337,840
GS-5	32	11,907	15,003	480,096
Totals	144			$2,411,170

5. Supplies

a. Alternative A. The current cost for forms, cards ribbons and other ADP related supply items is $550,000 per year. For alternative A, this value will remain constant throughout the life cycle.

b. Alternative B. For years one and two, supplies are the same as Alternative A. Starting in year three, supply costs increase 5% per year due to the increased workload.

VI. BENEFIT ANALYSIS

We identified some benefits and disadvantages with the proposed alternative.

A. Benefits

1. We can do our work faster, giving in better turnaround time for the users.

2. The new equipment has better reliability and has less chance to crash. If the system does fail, it will be easier to repair. Thus, this will reduce downtime of the system.

3. The new equipment will provide greater accuracy and eliminate batch processing. Data entry will be key to disk, thus eliminating keypunch errors. Reduction of input error will result in fewer corrections and fewer reruns.

4. The new equipment will retain a 33% surge capacity (third shift) to support crisis and exercise operation.

5. The current system does not meet minimum security requirements. We designed the proposed alternative to provide a high security environment.

B. Disadvantages

1. The continuity of operations will be interrupted during the migration period. The current staff is proficient in running the existing equipment. Still, they will require special training and on the job experience to become equally proficient in operating the new equipment.

2. The proposed alternative requires MILCON funding. If we do not get MILCON funding, we must delay our implementation.

3. This will eliminate many jobs in a geographic area with a high unemployment rate and depressed economy.

VII. COMPARISON OF ALTERNATIVES

A. Present Value Analysis. We did a present value analyses on Alternatives A and B. Tables E-7 and E-8 present this analysis. The results show that the discounted life cycle cost for the current system is $67,331,200 and the discounted life cycle cost of the proposed system is $63,947,900. Thus, the proposed system is economically feasible, yielding net discounted savings of $3,383,300.

B. Break-Even Analysis. Figure E-2 graphically displays the cumulative discounted costs for each alternative. The break-even point, when the cumulative costs for both alternatives are equal, occurs six years after implementation. Before then, Alternative A is less costly. After that, Alternative B becomes cost advantageous.

VIII. SENSITIVITY ANALYSIS

We did a sensitivity analysis to find if changes in certain input values would affect the outcome of our analysis. We tested three variables: conversion costs; Brand Z ADPE rental/maintenance and; timesharing workloads. We tested each factor independently by changing the original estimate by ten, 25 and 50 percent while holding all other parameters constant. Then, we calculated discounted life cycle costs for each alternative based on the new estimates. Below are the results of the three tests:

A. Conversion Costs. Table E-9 shows what would happen if conversion costs were 10%, 25%, and 50% higher than the original estimate. Since we would incur conversion costs only under the proposed alternative, the discounted life cycle cost of $67,331,200 for Alternative A will remain unchanged. Discounted life cycle costs for Alternative B would be:

	Undiscounted Conversion Costs		Discounted Life-Cycle Costs
	1979	1980	
Original estimate	$1,985,300	$3,639,700	$63,947,900
+10%	2,183,800	4,003,700	64,452,800
+25%	2,481,600	4,549,600	65,210,200
+50%	2,978,000	5,459,600	66,472,700

TABLE E-7

PRESENT VALUE ANALYSIS

ALTERNATIVE: A

($000)

PROJECT YEAR	NONRECURRING COSTS	RECURRING COSTS	TOTAL COST	DISCOUNT FACTOR	DISCOUNTED COSTS	CUMULATIVE DISCOUNTED COSTS
FY79		9,191.1	9,191.1	.954	8,768.3	8,768.3
FY80		9,475.1	9,475.1	.867	8,214.9	16,983.2
FY81		10,157.8	10,157.8	.788	7,980.7	24,963.9
FY82		10,574.7	10,574.7	.717	7,582.1	32,546.0
FY83		11,114.5	11,114.5	.652	7,246.7	39,792.7
FY84		11,819.4	11,819.4	.592	6,997.1	46,789.8
FY85		12,733.8	12,733.8	.538	6,850.8	53,640.6
FY86		13,922.0	13,922.0	.489	6,807.9	60,448.5
FY87		15,466.8	15,466.8	.445	6,882.7	67,331.2

TABLE E-8

PRESENT VALUE ANALYSIS

ALTERNATIVE: B

($000)

PROJECT YEAR	NONRECURRING COSTS	RECURRING COSTS	TOTAL COST	DISCOUNT FACTOR	DISCOUNTED COSTS	CUMULATIVE DISCOUNTED COSTS
FY79	$4,240.5	$ 9,191.1	$13,431.6	.954	$12,813.7	$12,813.7
FY80	3,447.5	12,633.0	16,080.5	.867	13,941.8	26,755.5
FY81		8,208.7	8,208.7	.788	6,468.5	33,224.0
FY82	723.5	8,377.9	9,101.4	.717	6,525.7	39,749.7
FY83		8,555.4	8,555.4	.652	5,578.1	45,327.8
FY84		8,742.1	8,742.1	.592	5,175.3	50,503.1
FY85		8,937.9	8,937.9	.538	4,808.6	55,311.7
FY86		9,143.6	9,143.6	.489	4,471.2	59,782.9
FY87		9,359.4	9,359.4	.445	4,164.9	63,947.9

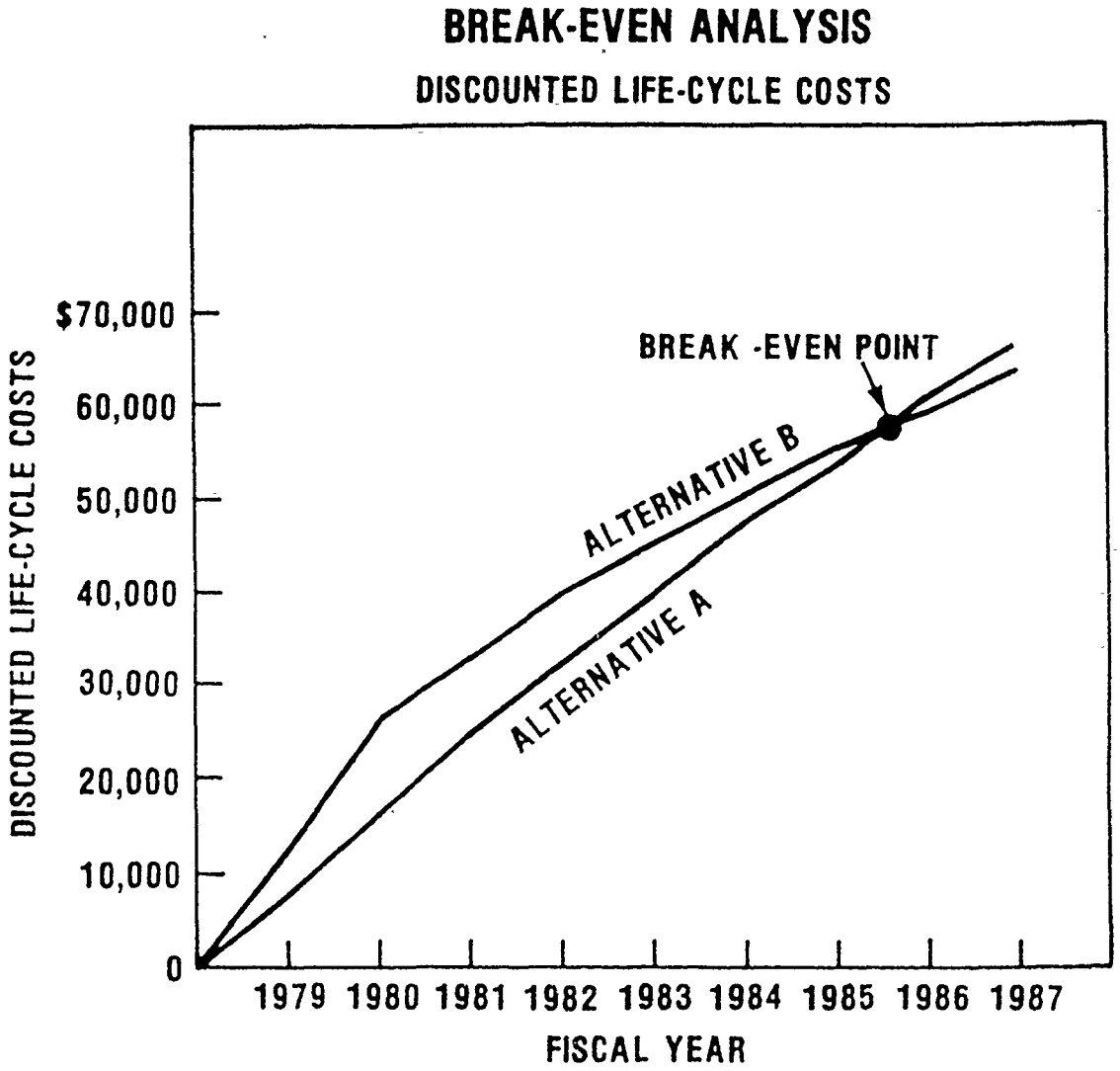

BREAK-EVEN ANALYSIS
DISCOUNTED LIFE-CYCLE COSTS
DISCOUNTED LIFE-CYCLE COSTS
$70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
BREAK -EVEN POINT
ALTERNATIVE B
ALTERNATIVE A
1979 1980 1981 1982 1983 1984 1985 1986 1987
FISCAL YEAR

Figure E-2

TABLE E-9

SENSITIVITY ANALYSIS

CONVERSION COSTS

($000)

FISCAL YEAR	DISCOUNT FACTOR	ALTERNATIVE A		ALTERNATIVE B					
		NO CHANGE		10% CHANGE		25% CHANGE		50% CHANGE	
		UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST
FY79	.954	$ 9,191.1	$ 8,768.3	$13,630.1	$13,003.1	$13,927.9	$13,287.2	$14,424.3	$13,760.8
FY80	.867	9,475.1	16,983.2	16,444.5	27,260.5	16,990.4	28,017.9	17,900.4	29,280.4
FY81	.788	10,157.8	24,963.9	8,208.7	33,729.0	8,208.7	34,486.4	8,208.7	35,748.9
FY82	.717	10,574.7	32,546.0	9,101.4	40,254.7	9,101.4	41,012.1	9,101.4	42,274.6
FY83	.652	11,114.5	39,792.7	8,555.4	45,832.8	8,555.4	46,590.2	8,555.4	47,852.7
FY84	.592	11,819.4	46,789.8	8,742.1	51,008.1	8,742.1	51,765.5	8,742.1	53,028.0
FY85	.538	12,733.8	53,640.6	8,937.9	55,816.7	8,937.9	56,574.1	8,937.9	57,836.6
FY86	.489	13,922.0	60,448.5	9,143.6	60,287.9	9,143.6	61,045.3	9,143.6	62,307.8
FY87	.445	15,466.8	67,331.2	9,359.4	64,452.8	9,359.4	65,210.2	9,359.4	66,472.7

In each cases, life cycle costs for Alternative B are less than Alternative A. Thus, the analysis is not sensitive to changes in conversion costs at these levels. We note sensitivity when we increase conversion costs by 67 percent. We found this value by doing the following algebraic break-even analysis.

Alternative A = Alternative B
$67,331.2 = $63,947.9 + $1985.3x (.954) + $3939.7x (.867)
$3,383.3 = $1894.Ox + $ 3,155.6x
$3,383.3 = $5049.6x
x = .67

B. Brand Z ADPE Rental/Maintenance. Table E-10 shows what would happen if Brand Z ADPE costs increased by 10%, 25% and 50%. This would not affect Alternative A. Costs for Alternative B would be:

	Annual Brand Z ADPE	Discounted Life cycle Costs
Original Estimate	$4,825,000	$63,947,900
+10%	5,307,500	66,402,900
+25%	6,031,300	70,085,300
+50%	7,237,500	76,222,700

The economic analysis is not sensitive to a 10% change. It is sensitive to changes of 25% and 50%. The actual point of sensitivity occurs when we increased Brand Z ADPE costs by 13.8% as follows:

Alternative A = Alternative B
$67,331.2 = $63,947.9 + $4,825x (5.088) $3,383.3 = $24,549.6x
x = .138

C. Timesharing Workload. Projected growth in timesharing workload was a major factor that led to the proposal to replace existing equipment. Because of the uncertainties associated with projecting future workload, we did a contingency analysis to see what happens if future workload is less than our projection. Table E-11 shows the results of the analysis. The future workload would affect both alternatives as we would incur the timesharing costs in either case. As Table E-4 identified, timesharing workloads decreased by 10%, 25% and 50%. The associated discounted life cycle costs are:

Alternative A	Alternative B
$65,918,100	$63,871,200
63,763,300	63,756,300
60,171,900	63,564,500

TABLE E-10

SENSITIVITY ANALYSIS

BRAND Z ADPE COSTS

($000)

FISCAL YEAR	DISCOUNT FACTOR	ALTERNATIVE A		ALTERNATIVE B					
		NO CHANGE		10% CHANGE		25% CHANGE		50% CHANGE	
		UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST
FY79	.954	$ 9,191.1	$ 8,768.3	$13,431.6	$12,813.7	$13,431.6	$12,813.7	$13,431.6	$12,813.7
FY80	.867	9,475.1	16,983.2	16,563.0	27,173.8	17,286.8	27,801.4	18,493.0	28,847.1
FY81	.788	10,157.8	24,963.9	8,691.2	34,022.5	9,415.0	35,220.4	10,621.2	37,216.6
FY82	.717	10,574.7	32,546.0	9,583.9	40,894.2	10,307.7	42,611.0	11,513.9	45,472.1
FY83	.652	11,114.5	39,792.7	9,037.9	46,786.9	9,761.7	48,975.6	10,967.9	52,623.2
FY84	.592	11,819.4	46,789.8	9,224.6	52,247.9	9,948.4	54,865.1	11,154.6	59,226.7
FY85	.538	12,733.8	53,640.6	9,420.4	57,316.1	10,144.2	60,322.7	11,350.4	65,332.2
FY86	.489	13,922.0	60,448.6	9,626.1	62,023.3	10,349.9	65,383.8	11,556.1	70,984.1
FY87	.445	15,466.8	67,331.2	9,841.9	66,402.9	10,565.7	70,085.5	11,771.9	76,222.6

TABLE E-11

SENSITIVITY ANALYSIS

TIMESHARING WORKLOAD

($000)

FISCAL YEAR	DISCOUNT FACTOR	ALTERNATIVE A						ALTERNATIVE B					
		10% CHANGE		25% CHANGE		50% CHANGE		10% CHANGE		25% CHANGE		50% CHANGE	
		UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST
FY79	.954	8,728.1	8,728.1	9,085.9	8,667.9	8,980.6	8,567.5	11,389.5	12,773.6	13,326.4	12,713.4	13,221.1	12,612.9
FY80	.867	8,153.8	16,881.9	9,298.9	16,730.0	9,122.6	16,476.8	16,038.4	26,678.9	15,975.3	26,564.0	15,870.0	26,372.2
FY81	.788	7,895.0	24,881.9	9,610.9	24,461.0	9,464.0	23,914.4	8,208.7	33,147.4	8,208.7	33,032.5	8,208.7	32,840.7
FY82	.717	7,452.6	32,229.5	10,123.6	31,719.6	9,672.4	30,869.5	9,101.4	39,671.1	9,101.4	39,558.2	9,101.4	39,366.4
FY83	.652	7,093.8	39,323.3	10,528.5	38,584.1	9,942.3	37,351.9	8,555.4	45,251.2	8,555.4	45,136.3	8,555.4	44,944.5
FY84	.592	6,816.9	46,140.2	11,057.1	45,129.9	10,294.8	43,446.4	8,742.1	50,426.5	8,742.1	50,311.6	8,742.1	50,119.8
FY85	.538	6,637.5	52,777.7	11,742.9	51,447.6	10,452.0	49,231.0	8,937.9	55,235.1	8,937.9	55,120.2	8,937.9	54,92[illegible]
FY86	.489	6,555.9	59,333.6	12,634.0	57,625.6	11,376.1	54,779.2	9,143.6	59,706.3	9,143.6	59,591.4	9,143.6	59,399.6
FY87	.445	6,584.7	65,918.1	13,792.6	63,763.3	12,118.5	60,171.9	9,359.4	63,871.2	9,359.4	63,756.3	9,359.4	63,564.5

The results show that the analysis is not sensitive at the 10% level. At the 25% level life cycle costs are about equal for both alternatives. This is the break-even point. If we decrease the timesharing workload by more than 25%, Alternative B would not be the least costly alternative.

IX. CONCLUSION

The results of the economic analysis showed that the proposed alternative is economically feasible. The alternative becomes cost effective six years after implementation and yields discounted life cycle savings of $3,383,300. We attribute major savings to the elimination of the timesharing workload. Besides being less costly, Alternative B can process the workload with greater speed, accuracy and reliability.

X. RECOMMENDATION

Based on the results of the economic analysis, we recommend Alternative B for implementation.

APPENDIX F

BIBLIOGRAPHY

Baris, Norman N., *Economic Analysis for Engineering and Managerial Decision Making*, New York, McGraw Hill Co., 1962.

Baumol, William J., "On the Discount Rate for Public Projects," in Robert Haverman and Julius Margolis, eds., *Public Expenditures and Policy Analysis*, Chicago, Rand McNally College Publishing Company, 1970.

Brigham, Eugene F. and James L. Pappas, *Managerial Economics*, Hinsdale, Illinois, the Dryden Press Inc., 1972.

Brown, Dick, "Cost/Benefit Analysis of Management Information Systems," Unpublished paper; American University, 1979.

Buffa, Ellwood S., *Operations Management: Problems and Models*, New York, New York, John Wiley and Sons Inc., 1968.

Canada, John R., *Intermediate Economic Analysis for Management and Engineering*, Englewood Cliffs, N.J., Prentice-Hall Inc., 1972.

Cost Comparison Handbook, Supplement No. 1 to OMB Circular No. A-76: Policies for Acquiring Commercial or Industrial Products and Services Needed by the Government, Office of Management and Budget, March, 1979.

"Cost Effective Analysis," in *Methodology Notebook for Action Officers*, 2nd ed., U.S. Army Combat Developments Command, 1967.

Dean, Joel, *Capital Budgeting*, Columbia University Press, 1959.

Discount Rates to be Used in Evaluating Time-Distributed Costs and Benefits, OMB Circular No. A-94, Revised, Office of Management and Budget, March, 1972.

Due, John F. and Ann F. Friedlaender, *Government Finance Economics of the Public Sector*, Homewood, Illinois, Richard D. Irwin, Inc., 1973.

Economic Analysis and Program Evaluation, 3rd ed., U.S. Army Communications Command, 1976.

Economic Analysis and Program Evaluation, Defense Intelligence Agency, 1973.

Economic Analysis and Program Evaluation for Navy Resource Management, SECNAVINST 7000.148, 18 June 1975.

Economic Analysis and Program Evaluation for Resource Management, DOD Instruction Number 7041.3, 18 October, 1972.

Economic Analysis for Decision Making, Course Book, Army Management Engineering Training Agency.

Economic Analysis Handbook, 2nd ed., Defense Economic Analysis Council, Jan. 1975.

Economic Analysis Handbook, NAVFAC P-442, Naval Facilities Engineering Command, June, 1975.

Economic Analysis Manual, 2nd ed., U.S. Army Munitions Command, 1973.

Economic Analysis of Public Investment Decisions; Interest Rate and Discounting Analysis: A Report, Joint Economic Committee, 90th Congress, 2nd Session, Washington, GPO, 1968.

Fischer, Gene, H., *Cost Considerations in Systems Analysis*, New York, New York, American Elsevier Publishing Company Inc., 1972.

Goldman, Thomas A., ed., *Cost Effectiveness Analysis*, New York, New York, Frederick A. Praeger, Publishers, 1968.

Grant E. I., W. G. Ireson, and Richard S. Leavenworth, ed., *Principles of Engineering Economy*, 5th ed., New York, New York, The Ronald Press Company, 1976.

Handbook for Preparation, Use, and Instruction of Economic Analysis, Pamphlet 37-2, U.S. Army Tank - Automotive Command, 1974.

Haviland, David S., "Life Cycle Cost Analysis: A guide for Architects," Paper prepared for the Life Cycle Cost Analysis Task Force, The American Institute of Architects, June, 1976.

Howe, Charles W., *Benefit-Cost Analysis for Water System Planning*, Washington, D.C., American Geographical Union, 1972.

McKean, Roland N., "The Nature of Cost-Benefit Analysis," in Erwin Mansfield, ed., *Micro-Economics Selected Readings*, 2nd ed., New York, W. W. Norton & Company, Inc., 1971.

Parsons, James A., "Matrix Methods: Break-Even Analysis," *Systems and Procedures Journal*, Sep-Oct, 1967.

Policies for Acquiring Commercial or Industrial Products and Services Needed by the Government, OMB Circular No. A-76, Revised, Office of Management and Budget, March, 1979.

Prest, A. R., and Ralph Turvey, "Applications of Cost-Benefit Analysis," in Erwin Mansfield, ed., *Micro-Economics Selected Readings*, 2nd ed., New York, W. W. Norton & Company, Inc., 1971.

Quirin, G. D., *The Capital Expenditure Decision*, Homewood, Illinois, Richard D. Irwin Inc., 1967.

Shishko, Robert, "Choosing the Discount Rate for Defense Decision Making," R-1953-RC, The Rand Corporation, Santa Monica, California, July 1976.

Smith, G. W., *Engineering Economy: Analysis of Capital Expenditures*, Ames, Iowa, Iowa State University Press, 1960.

Stockfisch, J. A., "Measuring the Opportunity Cost of Government Investment," IDA Research Paper R-490, March, 1969.

Swope, William H. and Erik K. Green, *A Guidebook for Economic Analysis in the Naval Education and Training Command*, TAEG Report No. 55, Training Analysis and Evaluation Group, Orlando, Florida, April, 1978.

Zimmerman, Denise C., *Economic Analysis*, DLAM 7041.1. Defense Logistics Agency, Alexandria, Virginia, March 1978.